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THE COLORADO POTATO INDUSTRY

BY

E. R. BENNETT

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THE COLORADO POTATO INDUSTRY.

A Preliminary Report Based on One Season's Study, Partly Aided by State Appropriation of 1905

E. R. BENNETT

THE POTATO INDUSTRY OF COLORADO has a number of peculiarities. The total yield of the state (8,000,000 bu.) as compared with some of the other great potato producing states is not large. In the East the great yield of potatoes comes not from any one area but for the most part from small acreages on each of the many small farms over the whole of a state. In Colorado the potatoes are grown only in certain restricted and well defined districts. On these areas potatoes are the most important product and the other crops are an adjunct to or an element in the system in the preparation of the land for this crop. It is not an uncommon thing in these districts to see fields of from forty to one hundred acres of potatoes on farms of a quarter section.

The problems confronting the growers in this State, as to cultural methods, insect pests and fungous diseases, are also radically different from those of the Eastern States. Many of the fertile irrigated tracts do not produce potatoes successfully, though they are near and similar in most respects to the so called potato districts. Why this is so has not so far been satisfactorily explained. The writer has spent the past summer in studying the conditions and methods under which the potato is grown in some of the more successful districts and comparing the methods employed at different places. Of the potato producing sections of the State, the irrigated land surrounding Greeley known as the Greeley District, the water shed between the Arkansas and the Platte Rivers known as the Arkansas Divide, a small section of the San Luis Valley, the Valley of the Roaring Fork of which Carbondale is the center and the Uncompahgre Valley are the most important. A few other small mountain valleys produce a limited quantity for the local mining trade.

The Greeley District exceeds all the others as to area and amount of potatoes produced. It is about twenty miles long from northwest to southeast and twelve or fifteen miles wide at its greatest width. It includes about 200,000 acres of land, though probably not more than one-eighth of this tract is ever put in potatoes at any one time. The total yield per year of this tract is from 9,000 to 14,000 cars or 4,000,000 to 6,000,000 bushels.

Comparatively few varieties of potatoes are grown in Colorado. Nearly all the known varieties have been tried at one time

or another and only a few have proved profitable. The districts differ somewhat in the varieties grown owing partly to the market demands and partly to the difference in soils, elevation and length of seasons of the different places.

THE POTATO INDUSTRY

THE GREELEY DISTRICT. Potatoes have been grown in this district since the foundation of the Union Colony in 1870. At first the bottoms of the Big Thompson produced the most, then the "blight," probably Rhizoctonia, became so bad there that practically none have been grown for several years. After the Big Thompson bottoms began to fail as a potato producing section, they were grown in and near the town to the south of Greeley. Then the blight became so bad that few could be raised in and around town which is mostly on the Laurel* sand loam of the river bottom. As the country north and east of town became broken up, the industry was given a new impetus. As the cultivated area grew the production of potatoes increased but was limited both as to area of land devoted to potato growing, and yield, till alfalfa was brought in as a part of the regular rotation about 1886. Previous to that time alfalfa had been grown to some extent but it was not thought possible to break it up successfully. From 1886 on, the yield of potatoes increased and potato growing as an industry became one of the leading occupations of the farmers north and east of the town. Mr. Boyd in his "History of Greeley" written in 1890 says: "the shipments for the past five years from the Greeley District have been from 1,000 to 1,800 cars a year." Now the shipments are from 8,000 to 14,000 cars.

The blight (Rhizoctonia) has given trouble more or less from the beginning. The Colorado potato beetle has caused some loss at times. Mr. Boyd says in his history of Greeley: "In 1889, fourteen thousand pounds of Paris Green were sold at Greeley and Eaton for spraying potato vines for the striped potato beetle." Locusts have occasionally caused some damage. On the whole, adverse conditions have been fewer than in most potato growing sections of the United States and the growth of the industry has been normal and constant.

The history of the other potato districts of Colorado is similar to that of Greeley.

THE CARBONDALE DISTRICT. Potatoes have been grown in the Carbondale District to some extent since its early settlement. Growing potatoes as a commercial industry, however, did not begin till within the last eight or ten years. At present the production

*U. S. Department of Agriculture, Bureau of Soils, 1904.

is limited only by the amount of irrigated land on the mesas and in the valleys of the Roaring Fork and Crystal Rivers. The soil and climate of these valleys are admirably adapted to the growth of potatoes. Owing to the high elevation and the proximity of high mountains, this district has a shorter growing season than the Greeley District and potatoes are planted correspondingly earlier. The soil is for the most part a red or blackish sandy loam on the mesas with a somewhat gravely soil in the river bottoms.

The methods of culture are similar to those practiced in the Greeley District. Alfalfa is rotated with grain and potatoes. One difference in practice is that seed is planted closer. The hills there are nine to twelve inches apart instead of thirteen to fifteen inches. The rows are also a little closer together being from thirty to thirty-six inches apart instead of thirty-eight or forty.

Few places can compete with the Carbondale District either in yield per acre or in quality of the product. The yields per acre vary on the different ranches according to the natural conditions of the soil and the fertilizers and methods of cultivation used but a high average yield is maintained.

Here as at Greeley nearly all the potatoes raised are of the late varieties. Early potatoes do not yield sufficiently well to pay, nor come early enough in the season to bring the maximum price of early potatoes. The most popular variety is the Improved Peachblow, sometimes known as the Red or White McClure. Other varieties are the Pearl, White Beauty, Carmon No. 1 and Challenge. The output for the valley is from 300 to 500 cars, or from 150,000 to 250,000 bushels.

Quite a large per cent of the West Slope potatoes find their way to special markets for hotels and dining car service. The remainder supply the mountain towns or are sent into the same markets as the other Colorado potatoes.

THE SAN LUIS VALLEY DISTRICT. The culture of potatoes in the San Luis Valley is somewhat different from that of the other potato districts of the State. The crop has been grown there since the early settlement of the State. Before the railroad was put through the valley, potatoes were freighted by wagon to Leadville and other mining towns.

Alfalfa is not grown to any extent in the valley but peas take its place in the rotation.

The soil varies in different locations but that on which potatoes are grown is a dark sandy loam underlaid with gravel. Sub-irrigation is practiced here. The gravel contains water at only a short distance from the surface so by running water in shallow ditches twenty or thirty feet apart, the water table is raised so that the moisture is brought to the surface.

The varieties grown are the Monroe County Prize, Rural N. Y. No. 2, Pearl and Champion. The yield is at present about 400 cars. Most of these potatoes are marketed in New Mexico or Texas.

The tendency toward running out is not so noticeable here or at Carbondale as in the Greeley District. In fact the same seed has been kept at both these places for at least fifteen years without deteriorating.

THE DIVIDE DISTRICT. The Arkansas Divide is the only place in the State of any extent where potatoes are grown without irrigation. Conditions cannot so well be controlled and the yield is correspondingly less. A specialty is made of growing potatoes for seed in this locality. As much of this seed is used in the Greeley District the same varieties are grown.

The culture given the crop is similar to the other places except that more surface cultivation is necessary to conserve the limited amount of water though the rainfall is considerably in excess of other parts of the State.

METHODS OF POTATO CULTURE IN THE GREELEY DISTRICT

Owing to the character of western soils, system of irrigation, large acreage of potatoes per farm and rotation of crops, the methods of potato culture in Colorado differ somewhat from those of other sections of the country. At first the methods of irrigation and cultivation best suited to the conditions here were not well understood but since it was found that alfalfa could be successfully broken up and that deep cultivation was most beneficial the methods have not changed to any considerable extent.

There is a prevailing opinion that potatoes require a certain kind of soil. There undoubtedly is a relation between the yield and quality of potatoes at certain places and the different soils. Just what this relation is, however, has not as yet been successfully explained. Good yields of potatoes are produced on several different soils and failures occur on all of them.

SOILS. The soils used for potatoes in the Greeley Potato District are: *Billings loam, Colorado fine sand, Colorado sand, Billings clay loam and to a certain extent Laurel sand loam.

The Billings loam is a heavy soil well mixed with sharp granitic gravel. It has a depth of from two to five or six feet. This soil is underlaid with gravel which gives good under drainage. More care has to be exercised in handling this soil because if worked when too wet or too dry, it is more liable to become lumpy than are the lighter loams.

The Colorado fine sand loam is intermediate between the Billings loam and the Colorado sand. It is generally deeper than

*U. S. Department of Agriculture, Bureau of Soils, 1904.

the Billings loam and does not pack or become lumpy so easily as the latter but on the other hand it contains less gravel. These two soils constitute by far the larger part of the successful potato district north and east of the town of Greeley.

The Billings clay loam is finer than either of the others. It has less gravel and is so deep that the under drainage is not good. This soil occupies narrow strips in the creek bottoms and while it often produces good crops of potatoes it is liable to serious attacts of fungous diseases.

The Colorado sand is coarser in texture, contains less nitrogenous matter and requires more water to produce a crop but where proper rotation of crops and cultural methods have been employed, good results are obtained.

The Laurel sand loam, which is the first bottom land of the Poudre River Valley, is not very different from the other sandy loams but in most places the water table is close to the surface and potato growing on this soil in not uniformly successful.

All these soils contain more or less alkali but not enough in most cases to prevent the development of plants except where water stands and evaporates.

PREPARATION OF POTATO LAND. The preparation of the land for potato growing is probably the most important item of the work. The difference between new land broken for potatoes, old land and alfalfa land is most marked. The new land produces a very clean grade of potatoes but does not give so good a yield as land either preceeded by potatoes or alfalfa. Alfalfa land gives the largest yields and is less liable to disease than where potatoes succeed potatoes. The universal practice is to rotate so as to preceed potatoes with alfalfa.

ROTATION OF CROPS. The most common rotation is alfalfa two or three years, potatoes two years or where beets are grown, potatoes one year, and beets one year, then grain two years. Sometimes wheat or oats are only grown one year but experience has shown that in the majority of cases, the first year of grain following potatoes or beets produces so much straw that the young alfalfa is smothered out if grown. The grain, owing to the reduced fertility of the soil, is not so large the second year and makes a better nurse crop for the alfalfa. Another rotation practiced to some extent is alfalfa two years, potatoes one year, wheat one year, potatoes one year, grain, then alfalfa again. This system while not very generally practiced has some possibilities in the way of "blight" control which will be spoken of later in this report. The number of years alfalfa should be allowed to grow to get the land in the best condition for potatoes is an open question.

While by far the majority of growers allow it to stand but

two years, it is the opinion of some authorities and many of the best practical farmers that it would do most good if left three years. Some think that even six or seven years would be better.

Winter sheep feeding has changed the rotation to some extent. When enough sheep are fed to produce a good coat of manure for the potato fields, potatoes are followed with potatoes twice or potatoes once and once with beets. Very substantial gains in yield of both potatoes and beets have resulted where manure has been used. The use of manure on land here as well as in the Eastern states is cumulative in its effects and benefits particularly the heavy soils in two ways. The physical condition of the soil is improved by being made more porous and friable so that it will hold moisture better and of course, plant food is also added to it.

PLOWING. In the preparation of the land for potato growing the plowing is not the least important. This is sometimes done in the late fall but more commonly in the spring from the latter part of April to May 15th. Fall plowing gives good results but ordinarily time for doing the work cannot be found at that season or the land may be too dry to make plowing possible. The depth of plowing ranges all the way from six to twelve inches but nearly as many plow eight inches deep as all other depths taken together. The work is generally done with four horses and a 14-16" plow. When alfalfa is being broken the plows used have a wide share so that all the alfalfa roots are cut off at the bottom of the furrow.

A practice that is to be commended in other places as well as on the irrigated land of Colorado is that of following the plow immediately with the smoothing harrow. This is done partly to mellow the soil and prevent the formation of lumps but mostly to conserve the moisture. Experiments have demonstrated that the loss of moisture by evaporation is much less where this is done than where the plowed land remains for a time without harrowing. In this State the practice is to harrow all the land that is plowed each half-day before leaving the field.

HARROWING AND LEVELING. In many fields scrapers are used after the first harrowing to fill the hollows and take down any ridges that are liable to cause trouble in getting water evenly distributed over the field. The amount of work required to fit the land for planting after the first harrowing and leveling depends on the character of the land. With average loamy soils one or two subsequent harrowings are sufficient to put the soil in perfect condition for planting. If the soil is heavy or has been packed by rains, the disk harrow is used and followed by the smoothing harrow.

PLATE I. CULTURAL OPERATIONS.

1. Furrowing. 2. Digging. 3. Cultivating. 4. Planting.

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PLATE II. Conveniences for Cutting Seed Potatoes. Notice the Knife in the Board.

PLATE III. Irrigating Potatoes—alternate rows.

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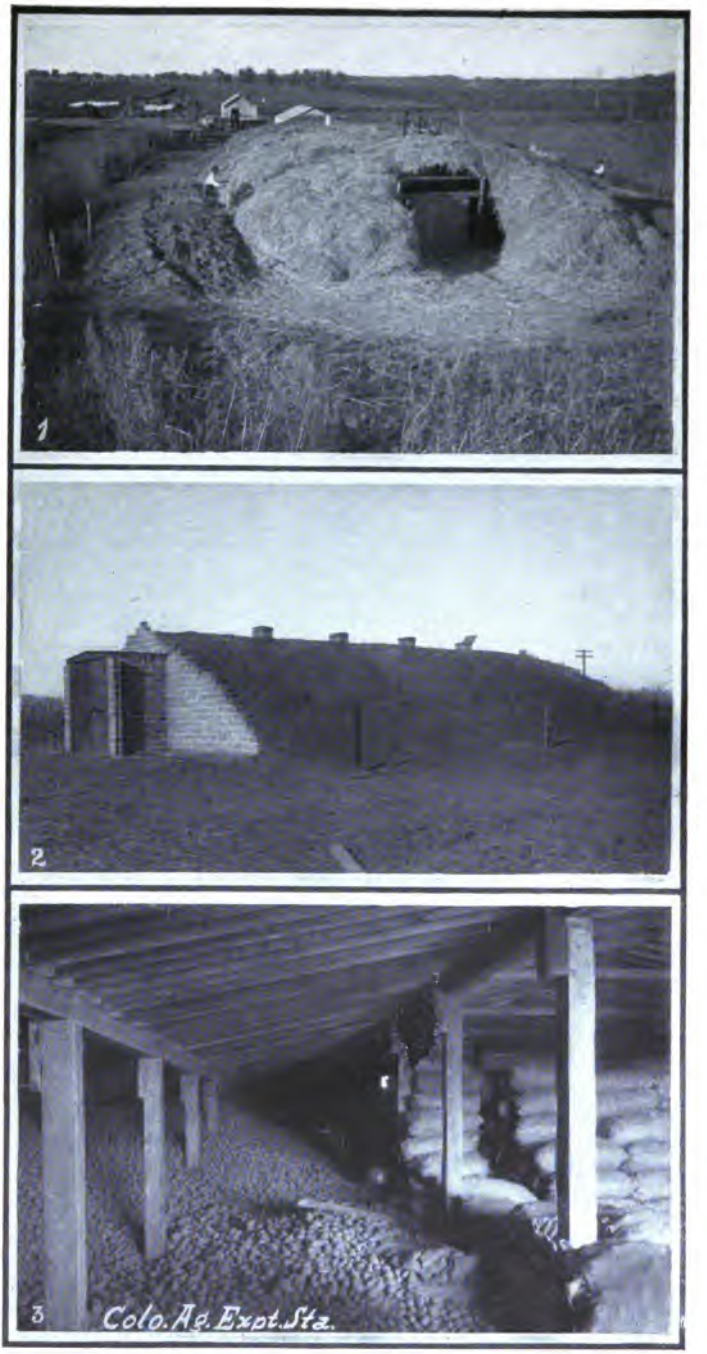

PLATE IV. POTATO CELLARS.

1. Process of Construction. 2. Exterior. 3. Interior.

PLANTING. Much diversity of opinion prevails among the growers as to the details of preparing seed and planting. The general practice is to select seed from the stock which is left over winter in the storage cellar for the spring market if home grown seed is used. If not, the seed is purchased from the Divide country, the mountains or from the East. Medium to small seed is used by the majority of growers. Some make a practice of "greening" the seed. That is the seed is spread in a thin layer on the floor of the dugout a few weeks before planting time. The ventilators and doors are left open to admit the light. Occasionally the potatoes are shoveled over to give a uniform exposure so that by planting time the tubers have become hardened and green, and the sprouts, if there are any are short and green instead of being long, slim and pale. The formailin or corrosive sublimate treatment is seldom used. Cutting is done by hand. The number of eyes depends on the variety as some varieties of potatoes have many eyes while others have few. The usual aim is to leave two eyes on a piece, but the rule is not arbitrary. In fact the work coming at the busy season makes it necessary to employ inefficient help so that some pieces are left with many eyes while others have none. A method of cutting shown in Figure 2, Plate I, is thought to facilitate the work to some extent. The potatoes are shovelled into a bin or hopper made of a dry goods box raised on legs. The back is made higher than the front so that the potatoes will run down to the opening. In the bottom are cracks to let out the soil that is shoveled up with the potatoes. The cutting is simple. An old case knife or a shoe knife is fastened to the end of a piece of plank or board in such a way that the potato can be pushed against the knife and fall from it into the basket beneath. The seed is planted soon after cutting as it is thought that the vitality of the buds rapidly becomes lowered as the seed drys out.

Various substances are used on the cut seed that are supposed to be beneficial by drying the cut surfaces and preventing the work of insects or fungi. Air slaked lime, flowers of sulphur and gypsum (land plaster) are all used by different growers. All these are used in the same way. The cut seed is piled on a floor, the material is scattered on and then mixed by shoveling the pile over till the dust is brought in contact with each piece.

VARITIES. Very few early potatoes are grown. Early varieties have frequently been tried but the yield is seldom satisfactory and the crop cannot be marketed in time to get a high enough price to make up for the deficiency in yield. Mammoth White Pearl leads all the other varities in acreage and generally in yield. Rural N. Y. No. 2 is second in popularity and some

Ohios and Snowflakes are planted. Nearly all the known varieties have been tried in this district at one time or another but none of them have been able to compete with those named. The long potatoes tend to become longer and roughened and in a year or two degenerate or revert to what is supposed to be the ancester of our present race of potatoes. Owing to this tendency for seed to "run out" the same stock is not used more than two or three years.

PLANTING. All planting is done by machinery. Among the different makes of planters used are the Aspinwall, the Evans, the Superior, the Robins and the Excelsior. All these planters require cut seed. Very little difference can be seen in the work of any of them. Four horses are used with these planters and five to seven acres planted is considered a days work. The rows are from thirty-six to forty inches apart, with a distance between plants in the row of thirteen or fifteen inches.

CULTIVATION. Very soon after planting the first cultivation is given. The ridge left by the planter shows the rows so the plants do not need to be seen. The object of the first cultivation is two-fold. First the tramping of the four horses used on the planter packs the ground solidly. This needs to be loosened to areate the soil and prevent loss of moisture by evaporation. Second the alfalfa or weeds that are starting are killed. For this work, four horses on a heavy four shovel John Deere type of cultivator are user. The shovels are set to run as deep in the soil as they will go which is from eight to twelve or thirteen inches. They are also set so as to throw the soil toward the potato rows, thus beginning the hilling or ridging process which is characteristic of potato culture in this locality. This operation leaves the soil loose but more or less lumpy, and with a rough uneven surface, especially on the heavy soils. The harrow immediately follows the cultivator to re-establish the soil mulch. These two operations destroy the young weeds so there is little trouble in keeping the field clean.

The number of cultivations depends upon the weather conditions and rapidity of growth of the vines. The cultivator is used a second time as soon as the plants are large enough so that the rows can be easily followed. This time the shovels are not run quite so close to the row but to the same depth unless the plants are much developed. In that case the inside shovels are raised so as not to injure the root system. Sometimes two cultivations are all that are given but ordinarily a third follows the second by a week or ten days and if the vines do not get too large or irrigation become necessary, cultivation is continued. Each time the cultivator is used more soil is thrown toward the potato rows

and the hollow between the rows becomes deeper, thus ditching is more easily done.

Ditching and irrigating are delayed as long as possible. The rule is not to irrigate if it can be avoided till the potatoes are in bloom or the tubers set.

DITCHING. The ditching is done with a narrow double mold board plow. Three horses are attached and the plow is run once in each row at about the depth of cultivation or ten to twelve inches. This ditching takes the place of one cultivation and if the ground is hard or if the first irrigation fills the ditches to any extent, the operation is repeated so as to make the ditches deep enough to keep the water below the surface of the potato ridges.

IRRIGATION. The details of irrigation depend upon the size and contour of the field to be irrigated. Many of the fields are arranged so that the rows are from one-fourth to one-half mile long. If the land slopes sufficiently and continuously across the field from the supply ditch, the problem is simple. At the first application the water is turned into a lateral at the head of the rows. A canvas dam is placed in the lateral so as to hold the water back and raise it into the rows. After the water has run in these rows a sufficient length of time to thoroughly wet the soil, the canvas dam is pulled out and reset farther down the lateral, and the water is stopped by blocking the heads of the irrigated rows with soil. In large fields the water is run in alternate rows only.

The head of water let into the rows depends upon the slope and length of rows. If the rows are short and the incline steep, the head must be small or the stream will reach the far side so quickly that enough water will not be used to thoroughly wet the soil. On the other hand, if the rows are long and the land nearly level the head of water is increased so as to force it along the rows faster, or a transverse ditch is cut through the middle of the field so as to shorten the distance that the water has to flow. If ridges occur in the field transverse ditches are run along at their top and irrigating is done both ways from it. When the water has run in the ditches till it seeps through to the unirrigated row, the soil is sufficiently wet. At the second irrigation the water is run in the rows not irrigated the first time. As the vines become large, the irrigation becomes more difficult owing to the lodging of the vines in the ditches, till at last considerable trouble is sometimes experienced to get the water through. On the other hand as the vines grow larger the soil is more protected from the sun so that the evaporation becomes less and the plants suffer less from want of water.

AMOUNT OF WATER USED TO GROW POTATOES. The number of applications and amount of water used per acre varies with the kind of soil and amount of rain fall. With average seasons the rain fall for May, June and early July is sufficient to bring up the plants and grow them till the tubers begin to form. Irrigation once begun must be continued at intervals of one week to ten days till the crop is developed. Four or five irrigations unless the season be a dry one will carry the crop through. A wide range of opinion prevails as to the amount of water that is best to use in irrigating potatoes. Most of the successful growers hold that in general too much rather than too little water is used. Some measurements taken on the E. R. Bliss ranch show the amount of water actually used in growing a crop of potatoes both on alfalfa land and on old potato land. The applications on a potato field which was preceeded by alfalfa were made as follows: July 25-26th the water ran 17 hours with a delivery of 4.05 feet per second. August 1 and 2, 27 hours with 1.96 feet per second. August 8 and 9, 24 hours at 2.31 feet per second and August 15 and 16, 30 hours at 2.37 feet per second. In all 893,916 cubic feet of water was used. This field was 1218 feet one way by 639 feet the other. This gives an area of 779,520 square feet or 17.88 acres, and a depth of water used in irrigation of 13.76 inches. The rain fall by months from April till October was: April, 3.04 inches; May, 1.73; June, 1.10; July, 2.24; August, .64 and September, 2.31, or 11.05 inches. The September rain was mostly in the latter part of the month and probably did little if any good to the potato crop. If the September rainfall is left out, the precipitation that should be counted as contributing to the growth of the crop will be 8.75 inches. The rainfall plus the irrigation gives us 22.51 inches as the total water used on the crop. This field had previously been in alfalfa for three years. It is Billings loam soil (clay loam) with quite a large per cent of sharp granitic gravel. The soil is about two and one-half feet deep, underlaid with gravel, so it has good drainage. The field was plowed in early May, eight inches deep, harrowed immediately and planted to Pearl and Snowflake potatoes June 1st. The yield of Pearls on this field was above 150 sacks per acre which is near the maximum for the season.

The field adjacent to this one which had grown potatoes the year before gave somewhat different results as to amount of water required, yield of potatoes and time of ripening.

The applications on this field were just previous to those on the alfalfa land potato field. The first run was 14 hours at a discharge of 4.05 feet per second and the second 18 hours at 1.96 feet per second, the third 16 hours at 2.31 feet per second

and the fourth 24 hours at 2.37 feet per second or a total of 668,232 cubic feet of water. This field was 1,300 feet long by 660 feet wide which gives an area of 858,000 square feet or 19.74 acres, and a depth of water over the field of 9.35 inches. The difference in the irrigating water between the old potato land and the alfalfa land was 4.41 inches. This field was planted just previously to the alfalfa field and the potatoes ripened (or the vines died from Rhizoctonia) about two weeks earlier. The yield was about 130 sacks per acre as against something over 150 sacks for the alfalfa land. Frequently a greater difference than this results between alfalfa land for potatoes and land preceeded by other crops. It would hardly seem that the difference comes from the amount of plant food in the soil for after potatoes have been grown on soil even three years, the cereals grown on it will produce heavy crops.

The difference in the amount of water can be attributed to the physical condition of the soil in the two fields. The decaying alfalfa stems and roots make the land more porous and the first irrigation particularly takes more water to fill the soil.

HARVESTING THE CROP. The potato harvesting is done so far as possible with machinery. The diggers used are the Peter Brown and the Doudon type of machines. With these the potatoes are plowed out and elevated over carriers that separate the tubers from the soil and leaves them scattered on the ground. Four or six horses are used on these machines. One machine will keep from ten to fifteen men busy, depending on the yield, picking, sacking and hauling from the field. While these machines are not perfect, they leave the potatoes well separated from the soil, providing the soil is not too wet nor the vines and weeds to numerous. Sometimes a harrow is run over the field before digging to knock down and tear out some of the vines that would clog the digger. When several rows are dug (depending on the number of pickers) the picking and sacking begins. The potatoes are picked in baskets and dumped onto the sorter. This machine is simply a frame on runners to which a horse may be attached to keep it alongside the pickers. On this frame, two seives, made of heavy wire, are placed, slanting to the back so that the large potatoes that will not go through the upper seive roll down into a sack. The smaller ones go through onto the lower seive which is a finer mesh and roll into another sack while the very small potatoes and soil fall through the second seive to the ground.

If the potatoes are to go direct to the market, the sacks are filled and set off on the ground. A man follows the sorter and with a needle and coarse twine closes the sacks by sewing up the top. The filled sacks are then loaded onto wagons and hauled

to the markets. These sacks are made of coarse burlap and hold from 110 to 120 pounds of potatoes. All potatoes are marketed in this way. Much expense in handling and loss from storing is avoided by this system of marketing direct from the field but on the other hand, the markets are often over supplied and the price reduced, by throwing such a large quantity of potatoes onto the market at one time. With the present conditions, however, the marketing of a large per cent of the crop from the field is necessary owing to lack of storage capacity on the farm. If the potatoes are to be stored in the "dugouts" or potato cellars, the sacks are only partly filled in the field then taken to the "dugout" and emptied into bins.

THE STORAGE HOUSE. The dugout or storage cellar is distinctly a dry climate or western feature. While its principles of construction would not adapt it to places of heavy rainfall, it is not only cheap but most efficient as a storage place for potatoes and other root crops in this climate. Being surrounded by soil on all sides, a nearly constant temperature is easily maintained. The loss from shrinkage by evaporation is also less than in ordinary cellars.

The construction of the dugout is simple. An excavation is made in the ground of the required dimensions for the cellar and of a sufficient depth to give soil for covering the top. A frame of posts. timbers and rafters is then made as for a building. This frame is covered with wire netting or brush. Over this two or three feet of straw is placed and this covered with soil to a depth of six to twelve inches. Figure 1, Plate IV, shows the method of covering the cellar with soil. Ventilator shafts are put in at regular intervals to give air circulation and keep the temperature from rising too high. Most of these dugouts have an alley through the center with doors at either end so that the wagon may be driven through. Double doors with a dead air space between are used as a protection against frost.

These dugouts are often filled to their full capacity in the fall to hold the crop for a rise in price. If they are stored while the weather is yet warm the ventilators and doors are left open nights to give a circulation of cold air and closed during the heat of the day. In this way the bins are gradually cooled down and by giving close attention to the temperature the whole mass is kept as cool as possible without danger from frost. During the winter considerable care has to be exercised to prevent the temperature of the dugout from rising from the heat developed by the stored potatoes. This is regulated by opening and closing the ventilator shafts as the case demands.

MARKETS

The position which Colorado occupies in respect to markets is one of the most important factors in making the industry profitable. Her geographical position is such that advantage can be taken of a shortage of crop either east or west of the mountains. And at the same time she is far enough away from the potato producing central states to avoid, to a great extent, the glutted markets that frequently occur when large crops prevail in the Mississippi valley and in the Lake Region. The cities of the east slope of the Rockies with Texas and New Mexico ordinarily get the large share of the crop but not infrequently the Pacific Coast, Central States and even New York and Boston are markets for the Greeley product. Practically all Colorado potatoes are put on the market in sacks. This system is somewhat more expensive than shipping loose in the cars as sacks cost from $6.50 to $8.00 per hundred. The system of sacking, however, has an advantage in that less time is required in handling the crop and the system is growing in favor in all the potato growing sections.

POTATO PESTS

The insect enemies and diseases of potatoes of Colorado are so different from those of the eastern states that the work done there on this subject is of little value to the Colorado potato grower.

INSECTS. The striped or Colorado potato beetle is a native of this state, yet the damage done by this beetle is now ordinarily so slight that no attention is given it by the growers. The flea beetle is, however, a serious pest. Comparatively little is known of the life history of this insect. There are several species similar in general appearance that do more or less damage. The worst one is the black flea beetle (Epitrix cucumeris). The last of May or the first of June these little flea-like beetles may be seen in quantities feeding on the weeds along the fences and ditch banks. They are black or dark brown, shiny and about one-tenth of an inch long. When disturbed, the insect jumps and disappears, a trick that gives it the name of "flea beetle." How they pass the winter is not known. Their presence is most noticeable by the appearance of the foliage that has been eaten, as the numerous little holes or light spots on the leaves of potatoes as well as tomatoes and the cucurbits are due to them. These perforations in the foliage injure the plant by rducing the leaf surface and also by giving entrance into the leaf of various plant diseases. Just how much the yield of tubers is cut down by this injury to the foliage is difficult to estimate. Later in the season the insect deposits eggs on the underground stems of the plants. The lar-

vae soon appear as very small white worm-like bodies on the potatoes or underground stems. These larvae are slender and from an eighth to one-fourth of an inch long. If tubers are carefully taken from the soil early in the season where these insects are prevalent, the larvae may be found burrowing into the tuber about one-third of the body being inside. At a casual glance they appear not unlike short root hairs growing from the surface. The injury caused by this insect produces the pimply effect so often seen in potatoes on the market and is often confused with or may be classed as one of the forms of scab. No practical remedy is known for this insect in this state. Spraying with Bordeaux mixture and arsenites destroyes or repells them but the expense of application of this remedy prohibits its use under the system of growing used here. When potato planting is delayed till June first, the injury to the foliage is avoided to some extent for by the time the plants are up the insects have sought other feeding grounds.

This insect is quite generally distributed over the country but is more prevalent in some places than in others and is also more numerous some seasons than others. The past season they have been particularly numerous, probably owing to the preceeding mild winter.

Not infrequently scabby or injured potatoes are infested with numerous small white worms so that there is quite a general opinion that the scabbiness or injury is caused by them. This is not usually the case. The injury or scab is caused by some other agent and the worms, which are saprophitic, work in the dead tissue and by so doing are credited with the damage. When earth worms are particularly plentiful the potatoes may be made dirty as a result of the worms crawling over them and leaving a slime to which the soil sticks.

FUNGOUS DISEASES. The fungous diseases of Colorado potatoes differ widely from those which cause the serious losses of the East. Early blight (alternaria) can be found but so far as is known little or no damage has resulted from it. The late blight (Phytophthora infestans) has never appeared at all.

CORTICIUM VAGUM B. & C. (*Rhizoctonia*). The serious fungous pests of Colorado are mostly those that work below ground. Bulletins Numbers 70 and 91 by F. M. Rolfs describe the one fungous disease that causes most of the loss to potato growers of this state. This disease evidently is not new to this locality for Boyd in his History of Greeley in speaking of the potato industry during the Seventies says: "For the first two years potatoes did well near Greeley on this side of the river. For some twelve years none could be raised in and around town. They did, as a rule,

OF
CALIFO

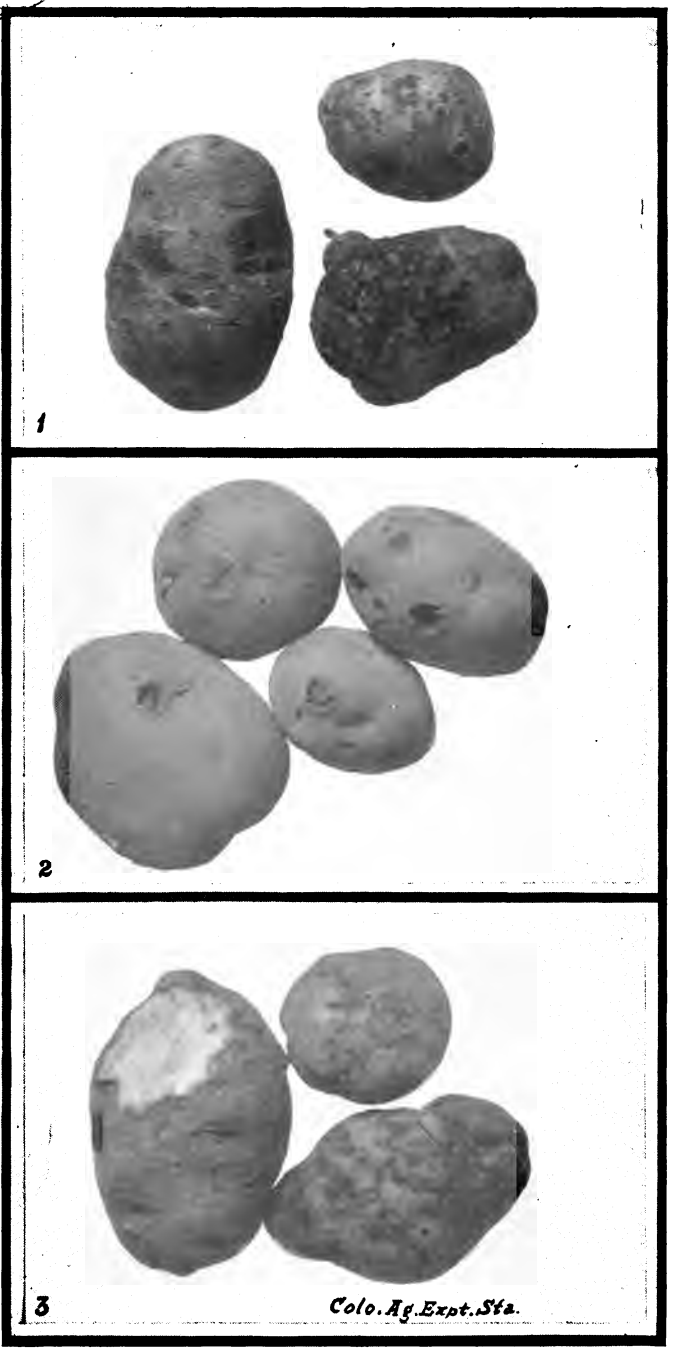

PLATE V. SCAB OF POTATOES.

1. Surface Scab. 2. Deep Scab. 3. Apparent Scab—work of the Beetle.

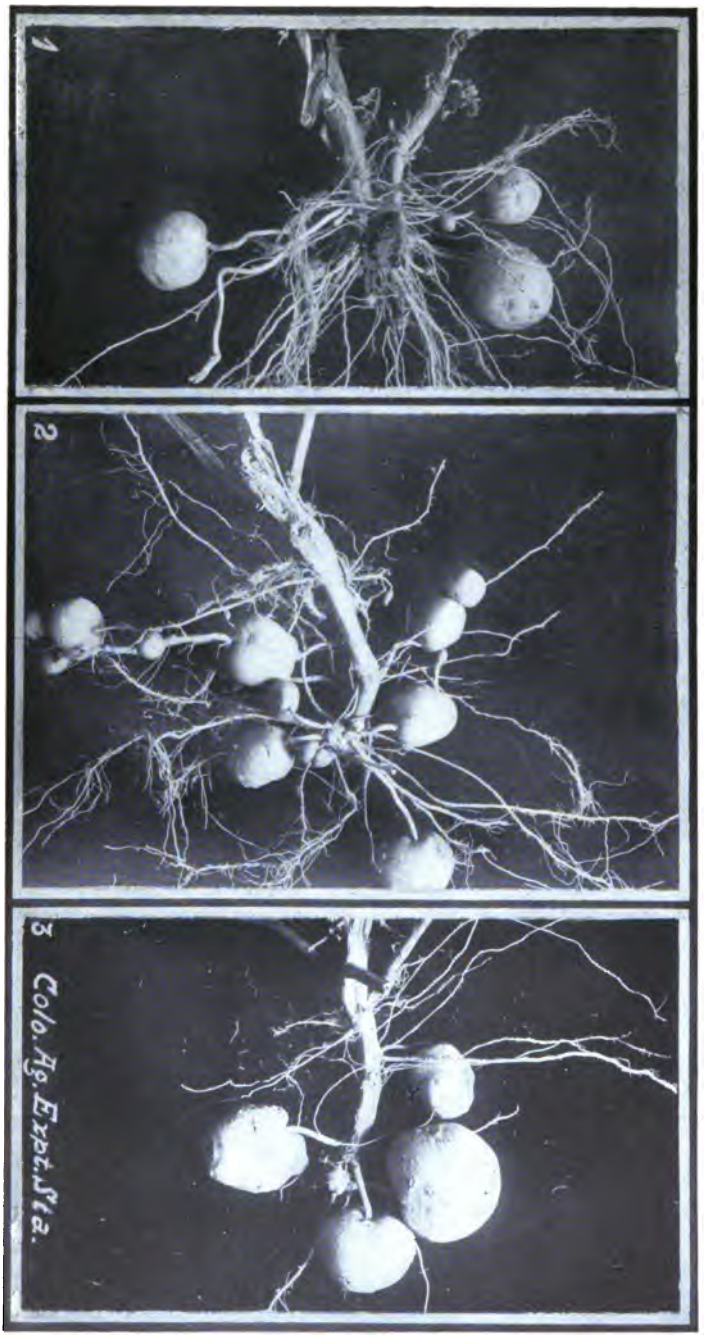

PLATE VI. HABITS OF GROWTH.

1. Rural N. Y., No. 2. 2. Improved Peachblow. 3. White Pearl.

no better on newly broken sod than on old sand. Heavy manuring of the land did not help the matter. The vines were struck with a rust or blight. This fungus made the leaves thick and stiff, and undoubtedly destroyed the sap and prevented the leaves from carrying on their function."

This is a good superficial description of the effects of this fungus as it looks in the field. From its past history it is evident that meteorological conditions have a strong influence on the behavior of this fungus. Probably there has been no year since the growing of potatoes began in this State that the disease has not been present, but much of the time, at least in the more favored locations, its attacks have been so light that it did not attract the attention of the growers. A high temperature, excessive moisture, alkali and a compact soil are all conditions that probably favor the development of the fungus. It has been generally supposed that this disease is introduced into the fields with the seed potatoes as nearly all seed tubers have more or less of the fungus on their surfaces in the form of scab or the black dirt-like patches of the sclerotia stage of the disease. Experiments with treating the seed with formalin and corrosive sublimate show, however, that the disease occurs just the same whether the seed is infected with the disease or clean. This fungus is not confined to the potato plant alone. In fact it is not known just how many plants act as a host for it. Peas, beans, beets, alfalfa and many weeds are known to be subject to its attacks. The curious fact remains that though the fungus works on alfalfa, potatoes following alfalfa are not generally as badly diseased and produce a larger crop than when they succeed themselves.

GENERAL APPEARANCE AND EFFECTS OF THE FUNGOUS ON POTATOES. To the ordinary observer, this disease does not become noticeable till the middle or latter part of the growing season. If the plants be examined carefully at any time from the first sprouting of the seed till the harvest, some of them will be found affected with the fungous. Plate II of Bulletin No. 92 of this Station shows the appearance of the disease in the first stages. Not infrequently if missing hills are examined at the time the plants are breaking through the ground the sprouts will be found to have started, but the stems have been girdled with a brown or black canker that stops growth. But if the injury is not serious enough to kill the plant at this stage, it will have a sickly yellow appearance and die soon after getting through the ground. From the time the plants first come up, all through the season, here and there through the field, will be found what the growers call "blighted plants." The leaves are thickened, and with the White Pearl especially, the leaves draw up close to the

stem so as to show the under side and give the ends of the vines a rosette appearance. Microscopical examination of the foliage or upper stems of these plants shows no traces of disease. If the plant be pulled from the ground, the stem will frequently be found scabby, black, or rusty with the center of the stem discolored. If the attack is unusually severe or in the last stages, the whole stem may be entirely decayed below the surface of the ground. In other cases the bark of the stem may seem fairly smooth and clean, but a split stem will show a discolored center. In this case the disease has started at the base of the stem, that is, at the junction of the stem and the old seed. Sometimes healthy looking vines will have rusty canker spots on the stems and no apparent injury result. It appears to be only those vines that are either entirely girdled or those diseased on the inside that are destroyed. The fatal effect on the plant of this disease comes from the hyphae of *Rhizoctonia* crowding into the cells of the stem and stopping the circulation by clogging. In cases where the disease works only on the outside of the stem, large vines with no potatoes are frequently produced or sometimes little potatoes are formed at the axils of the leaves all along the stems. The past season has been unusually favorable for the development of the disease. The loss from it in this state was probably not less than two and a half or three million bushels. The writer found here and there diseased plants in all fields visited during the early part of the growing season. Diseased plants gradually became more numerous, as the season advanced, but were not numerous enough to be considered a menace till the latter part of July, and the first of August, when a large part of many fields showed the disease. By the last of August growth had stopped in nearly all the fields and hardly a plant could be found that was not more or less diseased. Great variation in yield resulted. Fields of Pearls that developed early, yielded one hundred and fifty or more sacks per acre while other near by fields, particularly Rurals, did not exceed thirty sacks per acre. The question of yield this year seemed to be simply a matter of how far the tubers were developd when the growth was stopped by the fungus.

Experiments in the laboratory have proven, that at least a large part of the so called scab of potatoes in this state is a direct result of the action of this fungus. Sometimes it attacks the tubers causing a greater or less degree of scab without causing any apparent injury to the vines. Again both the vines and tubers are affected and frequently the vines are destroyed and no scab will appear. Some localities are so subject to the disease that potatoes can seldom be produced at all.

Why the fungus develops these peculiarities, what conditions

make it more prevalent in some localities than in others, and what remedies or methods of culture will prevent the loss from this disease are problems that are yet to be solved.

TREATMENT. Some experiments were made with treatment of soils with copper sulfate at the rate of thirty-five pounds to the acre to test its value as a preventative of the trouble. No effect either way could be detected. Cultural methods employed by different growers have also been carefully noted but with no definite results, other than that all the fields that produced satisfactory yields were given deep cultivation, while the small plots, as those planted in gardens even in the most successful potato growing districts, that were cultivated with one horse or kept clean with a hoe, produced nothing. Many fields that received deep cultivation were also failures.

SUGGESTIONS TO THE GROWERS

Although the potato industry of Colorado is new and only partly developed, the reputation of the product for high and uniform quality is known in all the markets of the country. Few places have the natural advantages for producing the high grade product that the irrigated potato sections of Colorado possess. Because of the high altitude the season is comparatively short without extremes of heat. The nights are cool. The amount of moisture can for the most part be controlled and the soils are deep and rich. All these conditions give the grower an opportunity to produce in the potato the same standard of excellence that is maintained by the fruit growers of the West.

We are not prepared to recommend many changes in the methods of culture practiced in the potato growing sections of this State, as those already in use are the results of a number of years experience in the application of scientific principles of soil management to a system of farming that is hardly known in the East. Undoubtedly the greatest need among the potato growers is organization. This is particularly true of the Greeley District. The compactness of the district, value of the property and large output of the crop, are factors that might make a growers organization there, a success, where in a more scattered or less wealthy community, good results would be less easily obtained. It is not our purpose in this report to suggest or recommend any scheme of organization. The advantages to be gained are many. At present there is no uniform system of grading. Scabby or misshapen potatoes may be put on the markets with the best grades. There is nothing to hinder potatoes from any place being sold as Greeley potatoes. With a registered trade mark and a uniform system of grading this could be prevented and the association

label on each sack would be a guarantee of quality, as is that of the various fruit growers associations in the West. Comparatively few consumers have any knowledge of varieties in potatoes. The people who buy Greeley potatoes and get a certain color and quality expect to get the same thing at the next purchase. If many varieties are grown and all go under one name disappointment is sure to follow and the reputation of the product is injured. Only a few varieties are now grown. One or two of these do better than any of the others so there is little reason for growing any but these standard varieties for the general market.

SEED TREAMENT

Results from the use of formalin or corrosive sublimate treatments have not been such that we can recommend their use. Both substances have caused more or less trouble from retarding the germination of the seed and in some cases the seed has been killed by their use. In these cases it is probable that the material was used too strong or the seed was left in the solution too long. Granting that the use of these materials will clean the seed of infection of the scab, the treatment is practically worthless so long as the soils are contaminated with the fungus. The so-called "greening" of the seed potatoes as practiced by some growers in the Greeley District is undoubtedly beneficial.

The treatment of cut seed should receive more attention than it ordinarily does. It is a well known fact that cut seed, allowed to stand for any considerable length of time, shrivels badly and the buds become weakened. Treating the fresh cut seed with air slaked lime, land plaster or sulphur tends to form a crust over the cut surface so as to prevent drying to some extent and they also tend to prevent the action of various fungi, worms and insects. These materials have not been experimented with sufficiently to know which of them is the best, but so far, observations of results have led us to favor the use of the flowers of sulphur as being more repellant to disease than the other two.

POTATO MACHINERY

The subject of machinery is one of general interest. All machines do fairly good work but none have been perfected. Nearly all the machines used in the state are made in the eastern states and are adapted to the conditions there. Some of the later models of planters are improvements on the older styles but none of them get a perfect stand of plants. Much depends upon the depth that it is desired to plant, and the depth of planting depends somewhat on the variety to be planted. Varieties differ consider-

ably in their habit of growth. Tubers are borne on root stocks or under ground stems that always grow from the stem of the plant above the old seed tuber. Figures 3, 1 and 2, Plate VI, show the characteristic habit of growth of Pearl, Rural N. Y. No. 2 and Improved Peachblow. The Pearl sends out short root stocks just above the old seed so that the tubers are formed closely around the center of the hill and at about the depth that the seed is planted. Rural N. Y. No. 2 has a longer rootstock and is apt to start higher above the old seed so that the tubers are more scattered in the hill. Some of them are deep in the soil and others will be close to or at the surface of the ground. The Improved Peachblow is still more irregular in its habit of tuber growth. These peculiar habits of growth make less difference under the hilling system of culture employed in the irrigated districts than where the level system is practiced.

With most machines the seed is planted too shallow rather than too deep. Many potatoes that are supposed to be planted four or five inches deep are really not more than one or two inches under the level surface of the soil. If the soil is sufficiently moist this does no harm but if the soil is dry at the surface, a poor stand is apt to result.

ROTATION OF CROPS AND RHIZOCTONIA

The rotation of crops as practiced in this state does not tend to lessen the amount of disease. The Rhizoctonia which causes the blight and a greater part of the scab of potatoes works on alfalfa as well as potatoes. So far as is known the disease does not live on the cereals so that is has been suggested that if potatoes could be preceeded by wheat or oats, instead of alfalfa, the amount of the disease might be lessened. The efficiency of a rotation of this kind is doubtful, however, as it is probable that the disease lives in the soil more than one year without any host plant, moreover the loss of the beneficial effects of alfalfa upon the soil would possibly be more than the ordinary loss from the disease.

SELECTION

A large part of the improvement in plants has been brought about through selection. This applies to plants propagated by vegetative parts as well as those propagated by seed. All the domesticated species are originated either from crossing or variations and are fixed in their particular characteristics by selection. The different varieties of a species may be called the variations of that species. When a variety is planted year after year it is sure

to revert or change its characteristics (that is run out) if selection of seed is not practiced. This is particularly true of a species that has such a great number of varieties as the potato. Varieties in this way are frequently subdivided into types. In a small way this may be seen in any potato field. A good example may be found in the Improved Peachblow. Some hills will be found that have from one to three large tubers with possibly a few very small ones. The large ones are apt to be cracked so as to be unsalable. Other hills may have one large tuber with several others grading down to the very small specimens. Now and then will be found a hill with from eight to a dozen medium sized perfect shaped tubers. Every man has in his mind an ideal type of the variety that he grows.

HOW TO SELECT SEED POTATOES

When digging, hills will be found, all the tubers of which will conform to this ideal. If these tubers be saved and planted, a large part though not all of them ought to produce potatoes like the seed. These should be selected again by hills and all should be discarded except potatoes from those hills which approximate the ideal type.

The longer this selection is carried on, the greater should be the proportion of tubers like the original selected type.

The usual objection to this selection, in practice, is that at digging time when the work must be done, the grower is too busy getting in the crop to take time for improvement of future crops. The selecting can be done, however, without taking a great deal of time. When the digger is running, one man should follow with a basket and select the most desirable specimens of tubers from hills that conform to his ideal type of that variety. Ordinarily the machine will leave the tubers in such shape that the individual hills can be separated. In this work do not look for perfect tubers only. Select perfect tubers from hills in which *all* of the tubers are of good shape and of sufficient number to give a good yield even though some of them are too small for market.

With this system of selection enough seed potatoes ought to be secured in one day to plant at least one acre of land. These potatoes should be sacked, *labeled* and put in a cool place by themselves. The following spring they should be planted at one side of the field where they can be staked off from the rest of the crop. Most growers prefer to plant potatoes, that are intended for seed, late. A very rich soil is not desirable for growing seed potatoes because of the tendency to produce overgrown tubers. This may be overcome to some extent by planting more seed to the hill or planting the hills closer together. When digging time comes the

same process of selection and elimination should be gone through again. In this way the improvement of type and yield may go on from year to year.

Many growers prefer green or immature seed to that which is fully developed. Experiments along this line with plants produced from seed rather than by vegetative parts have shown that immature seed tend to produce an early maturing plant and also one that tends to produce more fruit to the amount of plant tissue but at the expense of vitality and size of plant.

This law does not necessarily hold good with the potato since the reproduction is accomplished by means of the vegetative portion of the plant. Experiments along this line with the potato have not been carried far enough to give definite results.

COST OF GROWING

The cost per acre of growing potatoes varies to a considerable extent according to the soil, season and price of labor. One year with another an average of the different farms would not be far from the follwing figures which are taken from a pamphlet is sued by the Greeley Commercial Club.

Plowing land	$2.50
Leveling and harrowing	1.00
Seed Potatoes	5.00
Planting	1.50
Cultivating	2.50
Irrigating	1.50
Digging	7.50
Sacks	7.50
Marketing	6.00
	$35.00

This estimate is based on what is considered a good yield or from 200 to 300 bushels per acre. The first six items are practically uniform, whatever the yield may be, while the last three depend upon the yield per acre, so that a poor yield or a failure, reduces the cost per acre by about one half and an extremely large yield increases it accordingly.

The price of Colorado potatoes has a wide range from year to year, but the average price for the past ten years has been 65c per hundred lbs.

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The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Western Slope Fruit Investigation

1906

REPORT

Field Horticulturist

By

O. B. WHIPPLE

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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The Western Slope Fruit Investigation.

INTRODUCTORY.

A delegation of fruit growers of Mesa county appeared before the State Board of Agriculture in December, 1905, and requested help from the Experiment Station in questions troublesome to fruit growers of that vicinity, especially along the line of plant diseases, insect pests, and, subsequently, damage from seepage.

The Associated Fruit Growers of Mesa county felt the need of the work sufficiently to pledge $1,500 toward the cost of such investigation. The conditions surrounding the Experiment Station did not permit its funds to be used for that purpose. Realizing the immediate need, the State Board of Agriculture decided to appropriate money from other funds to carry on the investigation for the year 1906, until the meeting of the Legislature, with the expectation that the Legislature would enable the work to be continued.

The investigation in a general way was to include two men, a Field Horticulturist, and a Field Entomologist, with headquarters in Grand Junction, and subsequently seepage investigations were undertaken. The Field Horticulturist worked under plans prepared by Professor Paddock, and reported directly to him; the Entomologist worked in connection with the Field Horticulturist and also worked under the plans prepared by Prof. C. P. Gillette. The seepage investigations were under the direction of Professor Carpenter, and were carried on by Prof. E. B. House and Mr. F. L. Payne.

Under the instructions, every orchard in Mesa county was to be visited as soon as possible, and inspected, particular attention being given to spraying, pear blight, crown gall, woolly aphis and all orchard pests, cultivation, drainage and irrigation, and in fact, all orchard operations, and an orchard survey was to be conducted at the same time, and an endeavor to get the history of each orchard as far as possible. In this way, it is possible to find the causes contributing to successes and failures, and to decide what practices have proven most successful. Blanks were prepared for the study.

In the seepage investigation, a detailed study was to be made of the location of the seeped lands, and an attempt to determine the cause, in order to be able to prescribe a remedy. While it was expected that several years would be required, the scope of the work expanded, and with the development arising from experience, a smaller part was completed than expected.

The Field Horticulturist at Grand Junction is Mr. O. B. Whipple, who was transferred from Assistant Horticulturist at Fort Collins to take charge of the work. The Field Entomologist is Mr. E. P. Taylor, a graduate of the State Agricultural College of Fort Collins, and formerly Assistant State Entomologist of Illinois, and in the seepage investigations, Prof. E. B. House, of the Experiment Station staff, and Mr. F. L. Payne of Wichita, Kansas, who had before assisted in conducting similar investigations.

This is a report of the Field Horticulturist to the Director for 1906. It was not originally intended for publication, but it is believed it will be useful, and therefore is issued as a bulletin. The other related reports are in preparation.

It is desirable that the work should be carried on for a series of years and should extend as soon as possible to other fruit growing districts, as desired by Professor Paddock and the fruit growers of the Western Slope, and this continuation depends upon funds available for the purpose.

L. G. CARPENTER, Director.

Report of the Field Horticulturist for 1906.

O. B. WHIPPLE.

My time as field horticulturist has been largely devoted to the study of orchard conditions in Mesa county. During the season I have made two trips to Delta county to investigate the conditions there. I find it nearly impossible to divide my time to any great extent with other counties. After more experience in field work under these conditions the work can, no doubt, be carried on over a larger territory. Very little experimental work has been undertaken during the past season as it seemed best to follow conditions in the field one season that we might take up experimental work more intelligently the ensuing year.

In my work I have given special attention to plant diseases, cultivation, watering, pruning and the collection of data on the fruit industry.

The interest taken in the work by the growers has been very gratifying, and at no time have we experienced any difficulty in securing the co-operation of careful growers in carrying on experiments. The success of our work depends to a large extent upon this friendly co-operation of the fruit growers. Our correspondence with growers has not been all we desired but will no doubt increase as we become better acquainted and the plan of our work better known. Requests for information have been numerous but on account of the limited time spent in the office, some growers have no doubt become discouraged in trying to reach us by telephone. I have tried to spend as many evenings as possible in the office where I hope the growers will learn to find me.

The orchard survey work has not progressed as rapidly as we at first hoped it would on account of the time required for other investigations. This survey has been carried on in connection with other work as far as possible. This part of the investigations can no doubt be pushed more rapidly during the remainder of the year, and, while the summer season is the ideal time for this work, I think the object of the survey can be accomplished during the winter season.

PLANT DISEASES.

Observations on plant diseases have been very interesting and some important conclusions have been reached.

ALTERNARIA.

Experiments were undertaken during the season to determine the best method of controlling this rot which was thought to be damaging the fruit and foliage of Keiffer pear and Ben Davis and Gano apples. Three orchards were selected where severe injury was reported during the summer of 1905 and experiments outlined. Inquiries among orchard men led me to believe that a part of this injury, at least, might be due to spraying, and the experiments were planned with this point in mind. In one orchard a block of seventy-five Keiffer pear trees was selected and divided into blocks I, II and III. Block I was sprayed with Bordeaux mixture (3-4-50) on April 14th. The buds were well started at this time and were out far enough to expose the individual blossom stems. This block was again sprayed on May 8th with Bordeaux mixture (2-4-50), with 3 lbs. of arsenate of lead added to each fifty gallons of Bordeaux for the first codling moth spray.

Block II was sprayed on May 5th and 8th with Bordeaux applied at the same strength and with the same insecticide as used in block I, and was again sprayed with the same material on June 8th.

Block III was sprayed with arsenate of lead only, during the entire season. On July 10th block II was divided, and half was sprayed with arsenite of lime while the remainder and all other blocks were sprayed with arsenate of lead. A light rain followed and black blotches on the fruit were quite noticeable by the first of August. All other blocks sprayed with arsenate of lead during the entire season were perfectly clean. This indicates that the injury in the part of block II sprayed with arsenite of lime was due to burning.

In the second orchard a block of fifty Keiffer pears and a block of fifty Gano and Ben Davis apples were selected for experiments. The block of Keiffer pears was divided into two blocks and block I was sprayed on May 8th, or just after the blossoms had fallen, with Bordeaux mixture (2-4-50) with two and one half pounds of arsenate of lead added to each fifty gallons of Bordeaux. The brand of arsenate of lead used was of poor manufacture, and on May 23rd the check trees making up block II and sprayed on May 12th with arsenate of lead only, were found to be badly burned, while the foliage and fruit of block I showed no injury. The injury on block II was mostly to foliage though some fruits were burned, most of which dropped early. Block I was saved by the excess of lime in the Bordeaux which combined with the free arsenic in the lead. A good grade of lead was used on all blocks after this spraying.

Block I was again sprayed on June 9th with Bordeaux mix-

ture and arsenate of lead. No further signs of burning or Alternaria rot appeared on either block during the remainder of the season.

The fifty Ben Davis and Gano apples were sprayed with Bordeaux on the same dates as the pears, leaving the remainder of the orchard as a check. The owner being anxious to get the first codling moth spray on at the proper time, applied it five days earlier. Both blocks were injured severely by this first spraying with lead. Most of the injured fruits dropped early and at picking time no injury from burning or Alternaria was noticeable on the fruit of either check or sprayed trees. On the shaded portions of large trees sprayed with Bordeaux a slight russeting of the fruit was noticed but not serious enough to cause damage.

The experiments in the third orchard were practically the same, only on a smaller scale. A good grade of arsenate of lead was used and no injury from burning or Alternaria rot was found at picking time.

With these experiments, and after observations in many other orchards the following conclusions were reached:

First; that Alternaria is in most cases a secondary factor in causing the decay of fruit.

Second; that it does not seem to be able to gain entrance to the fruit through healthy tissue, unless it be in cases where it enters the core cavity through the calyx tube, but may follow any injury, as spray burn, bruises or worm holes. During the season it has been found under these conditions, as well as on blighted fruit spurs of the pear and in the germ cavity of peaches with split pits.

Third; that Keiffer pears cannot be sprayed with any degree of safety with other than a standard make of arsenate of lead. The nearer mature the fruit, the more liable it is to injury, and if possible, no sprays should be applied later than July 10th. With thorough spraying early in the season, applications later than this date are unnecessary.

Fourth; that if Gano and Ben Davis apples are to be sprayed with arsenite of lime, special care should be given to its preparation and a good clear day selected during which to apply it.

PEAR BLIGHT.

Pear blight has been severe on many varieties of pears this season and many neglected orchards are practically gone. Where reasonable care is given to cutting out affected limbs, most varieties are doing well. By very careful cutting, many growers are proving that pear culture is still profitable. A great deal may be accomplished, I believe, in selecting varieties. Comparisons made during the season of pear orchards seeded to grass with those under cultivation seem to show little difference in the amount of blight.

The Flemish Beauty, Clapp Favorite and Idaho, fortunately three worthless varieties from a commercial standpoint, should never be planted, as they blight badly. Not only this, but trees of these varieties should be taken out. While it is possible that these varieties may be worked over to other varieties to advan-

tage, it seems very probable from observations of the season that sooner or later blight will get into the trunk and kill the tree. So often does this seem to be true in the case of the Idaho that it would seem advisable to discourage the working over of this variety. Some of the commercial varieties which seem to be most free from blight are Keiffer, Anjou, Mt. Vernon, Garber, Howell and Seckel. Le Conte, Sugar, Bosc and Sudduth, four varieties not so well known, seem to be quite free from blight. Unfortunately when once attacked, Bartlett seems to suffer quite severely. Winter Nelis is fairly resistant, while Clairgeau seems to suffer severely from attacks in the trunk and larger branches. Persistent cutting out, I think, will do much to save the pear orchards. If it does not pay to cut out the blight, it does not pay to grow pears and owners of badly infested orchards should pull them out. Many growers pronounce their pear orchards the most profitable piece of land on the ranch, but these are men who cut out the blight. The general practice with these men is to cut out blight at least three times during the summer.

Blossom and twig blight in the apple seems to be on the increase and has attracted a great deal of attention the past season. It has not only caused a loss of crop, but a great deal of anxiety in regard to the future of the trees attacked. However, the only loss seems to be in the destruction of the crop before it has set, and the killing of whole fruit spurs carrying blighted blossoms. Only in a few sweet apples and in very severe cases has the blight done any damage to larger limbs. The general tendency seems to be for the blight to kill the spur back to the branch from which it springs and then die out. In especially bad cases in Tolman Sweet we have found branches of one and two year old wood killed. Even where the fruit spur is hardly more than a bud, it seems to be an exception for blight to do any damage to the branch from which it springs.

There seems to be some difference in varieties as to their resistance to blossom blight. All the sweet apples blight badly. The Ralls, Dr. Walker, Wealthy, Pewaukee and Jonathan are also subject to severe attacks. No varieties seem to be immune in badly infected orchards, but the Winesap, Gano and Ben Davis are as resistant as any. However it seems hardly possible to give definite lists, for there are exceptions, and the tables are often turned.

"Twig blight" is also bad in some varieties, as the sweet apples, Jonathan, Pewaukee, Red Romanite, Willow Twig and Transcendent Crab. In this case the blight rarely affects more than the current season's growth. Badly blighted pear trees neglected by the owner of the orchard or a nearby neighbor were often found to be the original source of infection in these badly blighted orchards. With more careful cutting out of pear blight,

I think the blossom and twig blight in apples would tend to decrease. Some growers have trimmed out all blighted spurs and, while it improves the looks of the tree enough to pay for the trouble, I hardly think leaving these spurs would increase the liability to attack the following year, as by mid-summer all blighted spurs are thoroughly dried and it would seem impossible for any hold-over blight to exist in them. I believe pear trees are, in the majority of cases, responsible for carrying the blight through to the next blossoming season.

PEACH MILDEW.

Probably owing to the unusual amount of rain during the early part of the season, peach mildew has been of more importance than usual. Losses from those of small per cents to those of total crops have been reported. Measures used in combatting this disease should be of a preventative nature rather than as a cure. After the fungus has once obtained a good foothold on the fruit, nothing can be done to save the peach. The fungus may be killed, but the flesh underneath refuses to grow and at ripening time we have a one sided peach or a peach with a sunken spot on it. The disease is capable of destroying a crop in a short time and prompt action is important.

Observations made in orchards where the attack was severe show that one thorough spraying with half-strength Bordeaux (2-4-50) will destroy the mildew. Thorough winter spraying of infested orchards with full strength Bordeaux should prove a very important safe-guard. The first appearance of the disease in early summer should be followed by prompt action on the part of the owner, and the orchard thoroughly sprayed with half strength Bordeaux. A week's delay in some orchards often means a loss of fifty per cent of the crop and two weeks a total loss.

GUMMOSIS.

Cases of Gummosis in peach trees have been found occasionally. Gum starts to flow from the trunk or larger branches during the early part of the summer and large drops are formed on the bark, often reaching an inch in diameter and are nearly as round as marbles. In severe cases the tree dies in the latter part of the season. While the number of cases reported need cause no alarm, the loss of a single tree in an orchard does not add to its value, and with reasonable care, I think the loss might be avoided.

While no large number of trees have been treated, experiments seem to show that a vertical slitting of the bark about the affected trunk or branch during the early stages will save the tree. Use a sharp knife for this work and do not be afraid of cutting too deep. Make the cuts about two inches apart. While I do not pronounce this a sure cure in all cases, it seems worthy of a trial on trees in the first stages. When the drops of gum reach the size of marbles, the tissues are broken down to such an extent that no practical method of treatment would save the tree.

ROOT ROTS.

Two apparently distinct forms of root rot are found. One form, which is proving the least destructive of the two, seems to show no preference for varieties, and confines itself to that part of the tree below the ground. The other seems to work exclusively on the Ben Davis and Gano, and the trunk as well as the roots are affected. The disease often extends upward into the large branches. The first indication of the disease is the appearance on the trunk of spots of a chocolate color. When peeled off the bark has a peculiar marbled appearance, the diseased portions standing out in sharp contrast to the healthy tissue. The disease soon kills the bark and it dries down to the wood, taking on a dark brown color. Two seasons are required for the disease to kill the tree. The first season the trunk is girdled and the foliage drops early. This early ripening of the foliage is often the most prominent symptom, and diseased trees can be easily picked out in the early fall. Trees showing an early bronzing of the foliage are generally found girdled by this disease. The second season the tree starts into leaf as the normal tree, generally setting fruit, and dies in mid-summer, the fruit and leaves clinging. The disease seems to be infectious, as the trees appear in groups, and in many cases it appears as though it were carried by water. When a diseased tree is found, several more are generally found in the same row. However, other varieties besides the Ben Davis and Gano may stand in the same row with diseased trees on either side and show no sign of contracting the disease. The fact that Ben Davis and Gano are very tender as regards the application of arsenical sprays has suggested to my mind that the trouble may be due to arsenic collecting about the crown of the tree and killing the bark. However, the fact that trees sprayed with arsenate of lead and arsenite of lime are alike affected, seems to be contrary to such a hypothesis.

Prompt removal of the trees affected seems at present to be the only treatment that can be suggested. Reports indicate that the disease has only been in the orchards two or three years at the most. Soil conditions seem to have no relation to the disease, as it is found on all kinds of soils.

CROWN GALL.

Only a few cases of crown gall have come to my observation in Mesa county, a few trees having been killed by it. A disease which appears very much the same and no doubt the same disease that is called crown gall by other stations, seems to be doing considerable injury to the Vinifera vineyards of this section. Rose of Peru seems to suffer most severely. Muscat, Tokay and Cornichon have been found affected, however. When the disease attacks the crown of the plant, death seems to follow in one or two years. When the canes are affected, growth seldom starts from above the gall, but new growth starts from below and the plant keeps alive, but bears very poor crops. While it is probably transmitted from plant to plant in the vineyard, this is uncertain, but observations in the vineyards seem to bear out the statement.

I think it would be well to remove diseased vines and give closer inspection to nursery stock. Under the present system, grapes are passed without inspection.

PHYSIOLOGICAL TROUBLES.

Many yellow pear trees are found in the valley. Observations seem to indicate poor soil conditions, probably due in most cases to excessive watering. The foliage takes on a yellow cast, and in the last stages the leaves become thickly sprinkled with small deadened spots and fall from the tree. The trees grow more enfeebled from year to year and are finally pulled out.

SMALL PEACHES.

Many growers claimed that their peaches did not attain the customary size while they were very sure that they had thinned as carefully as in previous years. There is no doubt some truth in the assertion and also a cause. The peach trees were severely frozen in most localities during the winter of 1904-05. Not only were the peach buds killed, but the wood was damaged to quite a serious extent. Many of these trees were not pruned as heavily as they should have been following such a freeze, and did not make

a good recovery. The winter of 1905-06 was less severe and the fruit buds passed the winter safely. While the growers thinned their peaches as carefully as usual, the trees, having failed to fully recover from the severe freeze in one growing season, were unable to mature the normal crop. Where severely pruned, the trees matured their crop well. Following severe freezes which injure the wood, it would be well to thin the first crop more closely.

COPPER SULPHATE INJURY.

Copper sulphate has been placed about trees with injurious results by some orchard men. When taken up by the roots the material blasts the foliage and causes it to fall. The most telltale effect is a blackening of the outer ring of the sap wood and cambium. When taken up by the roots in a concentrated form, the wood and bark near the base of the tree are killed in strips of varying width. Nearer the top where the material spreads more, the tendency is for the leaves to drop, and later a new growth starts. The upper limbs probably recover. The strips of bark on the trunk and limbs, however, seem to be perfectly dead.

The stock solution used in spraying with arsenite of lime, prepared by dissolving white arsenic in water and sal soda, is very destructive to plant life. The general practice of keeping this solution in the orchard under a tree should be discouraged. If a small amount is spilled, or if the vessel leaks, the material will soon kill the tree. In fact, it almost appears as though in some cases the material will kill peach trees when placed under them in an open vessel. The fumes given off when boiling this solution will kill trees without a doubt, and this boiling should be done some distance from the orchard. I have seen trees standing twenty feet from an open packing house door killed on the side next to the packing house in which the material was boiled.

Some Ben Davis and Gano orchards have shown a very sickly yellow color during the summer, and investigations have shown that the trees were suffering from arsenical poisoning. The trees were sprayed with arsenite of lime in which the quantity of lime used was deficient, or with an arsenate of lead which contained a large amount of free arsenic. The growth of foliage is scant and the color yellow. Though the material may have been used only once, the effect seemed to last through the season. There seems no reason to believe but that the trees will recover the coming season.

THINNING APPLES.

Experiments were undertaken in thinning apples during the early part of the season. An orchard was selected in which large

blocks of Jonathan and Winesap were carrying a very heavy load. The thinning was done in the early part of July. The apples were actually counted on some trees and a definite number left. Assuming that from 150 to 160 apples of these varieties make a box of fancy apples, the trees were thinned to produce from six to twelve boxes. The trees were eleven years old and the best results on the Jonathan seemed to come from trees yielding eight boxes, running about 160 apples to the box. Trees bearing more than this, run smaller in size and less uniform. The Winesap gave better results when thinned to about six or seven boxes. Trees of Jonathan thinned to eight boxes would yield 95 per cent or over fancy fruits as far as size and color were concerned. Unthinned trees which packed about sixteen boxes gave 50 per cent of small fancy fruit, but on the days the thinned trees were stripped not 50 per cent could be picked from the unthinned trees on account of poor color. At least 25 per cent did not reach a good color. Thinned trees which picked twelve boxes required two pickings and run on an average about 90 per cent fancy. These trees averaged about fifteen feet in height and had a twenty foot spread.

Observations will be made next season on the thinned and unthinned trees to determine the effect of thinning on the ensuing year's crop. The rule followed was to leave only one fruit on a spur and remove those from the tips of limbs. Observations on unthinned trees showed that apples on the tips of limbs seldom reach a good size.

GRAPE GROWING.

The associations and growers have complained of poor results in shipping grapes. The trouble seemed to be that they molded before they got to market. Correspondence was taken up with California growers and observations carried on in the vineyards during the season.

From California rules, and from my own observations, I believe the growers use more water than is necessary. In one case, I actually found the bunches shriveling from excessive watering.

The reason some varieties do not ship well is no doubt because they are not ripe enough. The short season does not give them time to thoroughly mature. The California people say a grape must be ripe to ship well. Another point, I believe, is carelessness in packing, in not cutting out injured berries nor allowing the stems to wilt. Grapes packed tight while the stems are stiff crack easily and this gives entrance to mold. Owing to the method of pruning practiced to allow of easy covering, many of the bunches come in contact with the ground and should be thoroughly dried before packing. Experiments have been taken up to determine a more

satisfactory method of pruning which will hold the grapes off the ground and still allow of the vines being easily covered. The general tendency seems to be to prune too short, and light crops of inferior bunches are the result. No varieties should be pruned shorter than four eyes, and the Muscat, Sweetwater, Sultana, Emperor and Thompson Seedless should be pruned to eight. Some system of training must be found which will hold the fruit off the ground. More care should be given to watering. Three waterings, I believe, are enough. Dry soil conditions should prevail during the ripening period.

As to varieties, the Flame Tokay and Cornichon seem best adapted to the Palisade region where early frosts do not strike. For the rest of this district, Muscat, Rose of Peru, Tinfadel and Chasselas Victoria must be used. Flame Tokay may succeed on early soil where the soil conditions can be well controlled. Thompson Seedless, Sultana and Sweetwater do well, but do not sell.

Grape mildew (Uncinula spiralis) has caused some loss in vineyards, and experiments have been started this fall to determine the best method of controlling it. One block was given a fall treatment of Bordeaux before covering, and other blocks will be sprayed the coming season and various fungicides tested.

Experiments were undertaken to show the value of sacking Vinifera grapes to protect them from rots and mildew and to improve their appearance. The cost of sacking was found to be about one-half cent per pound for most varieties, while those producing larger bunches can no doubt be sacked at one-half this cost. The earlier varieties seemed to fare very well in sacks, unless they were subject to cracking, as some of the more tender skinned varieties are. Bunches in sacks laying on the ground split and molded badly. For the late varieties sacking proved to be a failure as it retarded the coloring and ripening and seemed to give no protection from frost. The stems were frozen the first frosty night and the bunches wilted and failed to ripen. The Muscat and Thompson's Seedless did very well sacked and their appearance was much improved.

SETTING YOUNG TREES.

Practically all the systems of laying out orchards and planting young trees are used in the fruit sections of western Colorado. The distance of setting varies from 16'x16' to 30'x32' for apples and from 12'x12' to 20'x20' for peaches, but the experienced growers are giving the greater distance.

The practice of setting Missouri Pippin, as fillers, in with the standard varieties of apples is quite common. In the peach districts peaches are often used for the same purpose. I hardly think the practice is to be encouraged, as the average grower will not take them out

before they crowd. The tendency is to leave them in until the shape of the other trees is ruined.

Trees as a rule are not handled carefully in transplanting and a larger per cent is lost than is necessary. The most common method of setting is to plow a furrow and with a little additional digging, set the trees in this. For the first watering, the water is generally run through this furrow. It is then filled, or left open for other waterings. Many leave it open the whole season, but it is generally thought best to fill it in and water from the sides before the sun gets too hot. The practice of leaving this furrow open for most of the summer seems to give good results, but there is a tendency, I believe, to set too deep. I think it a very good method if the furrow is very shallow. The most common method of watering is to fill this furrow after the watering at planting time, and run new furrows on either side of the row and as close as possible. This system will give excellent results if the man who is irrigating sees that water passes all the trees properly. It is possible to water trees too often, however, and the man who is inclined to water too heavy should keep his ditches at some distance from the trees. With a scant supply of water, the system of watering in the original furrow in which the trees were set will give the best results. Young orchards are either cultivated, or planted to secondary crops. The most common secondary crops are cantaloupes, potatoes, corn, oats and white beans. Cantaloupes do well on the lighter soils but other crops are generally sown on heavy soils. Oats is a poor crop for the young orchard, as it is generally cut just in time to force the grasshoppers to eat leaves and bark from the trees before frost. The cutting of any noticeable growth in the orchard at mid-season is a dangerous practice on this account. On sandy soils cantaloupes are proving a favorite crop. The furrows for watering the cantaloupes should be as far from the tree rows as possible that late watering of the trees may be avoided. This is very important in young peach orchards. Many inexperienced growers water their peach trees too late, and as a result, have them killed back during the winter.

Young trees are seldom pruned carefully enough after the first year, and long, willowy branches which bend to the ground with the first load of fruit is the result. Greater distance in planting should be urged and more care in regard to the forming of the young tree. Too many second class trees are set, the growers failing to realize that a poor tree is dear at any price.

GENERAL ORCHARD CONDITIONS.

It is a general practice among orchard men to water too much and neglect cultivation, and often the soil is handled very poorly. A large per cent of the soil is rather heavy to be handled well under

irrigation, and with the method of watering commonly used, it is often impossible to touch these soils with the cultivator from the first watering in early summer until the following spring.

It is often the case that shallow furrows and a large head of water are used and the result is a flooding of the whole surface. When dry enough to work again, the soil has run together and the surface is so hard that it is impossible to cultivate it, and the grower resorts to frequent watering to keep the orchard going. In these soils the water settles slowly and a smaller head run in deeper ditches would no doubt prove more satisfactory.

I think growers with these heavy adobe soils should also resort to the planting of cover crops to improve soil texture They could gradually be brought into shape where they could be more easily handled after irrigation. Growers, as a rule, pay too little attention to the sub-soil. Too often, the rule followed is, if you can kick up dust on the surface, irrigate. The appearance of the tree indicates to a great extent its needs, but after all, it is an examination of the sub-soil which most surely determines whether the orchard needs water or not.

General rules which it might be well for growers to follow in applying water are as follows:

The more sandy the soil, the greater the number of ditches, the shorter the run in both time and distance.

The longer the ditches, the larger the head.

The stiffer the soil, the fewer and deeper the ditches, the longer the run in time and distance, and the smaller the head.

PROBLEMS FOR THE ENSUING YEAR.

Some of the problems for the coming year as brought out by this season's work are as follows:

Pear Blight and its control, giving especial attention to the form known as blossom blight in apples.

Peach mildew and the effects of lime-sulfur wash as a winter spray in comparison with Bordeaux mixture.

Grape mildew (Uncinula spiralis) and its control and the effect of winter and summer spraying.

Observations on grape growing in general with reference to watering, pruning, packing and shipping.

Further study of the root-rots of apples to determine, if possible, the causes and remedies.

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Western Slope Fruit Investigation 1906

Report of

The Field Entomologist

—BY—

E. P. TAYLOR

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WESTERN SLOPE FRUIT INVESTIGATION

Report of Field Entomologist*

SEASON OF 1906

E. P. TAYLOR, GRAND JUNCTION, COLORADO

The principal lines of work for the season have been—

(1) Experiments upon practical methods of controlling the principal insect pests of the orchard.
(2) Collection and study of other economic insects.
(3) Visitation of orchards by request or otherwise.
(4) Attendance at fruit growers' association meetings, farmers' institutes, county fairs, horticultural society meetings, etc., where questions relating to the work of this office were being considered.

The experiments carried on with injurious insects have been in cooperation with orchard men whose loss from these pests has invited tests of measures of control. The experiments have served as practical demonstrations in each neighborhood in which they were carried on, and have served as object lessons at the same time they were revealing new facts. They have been the objects of the deepest local interest. The territory covered by the demonstrative experiments has been thus far limited to points lying in the lower Grand Valley, principally in the orchard sections surrounding Grand Junction, Palisade, and Fruita.

CODLING MOTH. (*Cydia pomonella* Linn.)

Introductory—The codling moth has received the greatest share of attention. Spraying experiments have been completed in five orchards of the locality and the results successfully answer the principal questions relating to the control of the insect.

Probably no district in the United States is better equipped with modern spraying apparatus than the orchard district of Grand Valley. Nearly $100,000 are invested in spraying apparatus in the county of Mesa alone, but in spite of this fact, codling moth ravages have injured the fruit to the extent of a great many hundreds of thousands of dollars annually for some years past, and in spite of the fact that some orchardists have applied as many as ten or more sprayings per season. The past season has cost the growers, by careful estimate, over $36,000 for material used in making up their

*This bulletin is a companion to Bulletin 118, which gives the report of the Field Horticulturist for 1906, Western Slope Fruit Investigation.

The general plan for the entomological investigations were made by Prof. C. P. Gillette, and the work was under his direction.

The work was rendered possible by other funds than the government appropriations for the Experiment Station, a considerable portion from the fruit associations of Mesa County, and the remainder from the State Board of Agriculture.

arsenical sprays. This season's work has determined these failures to be due to several causes: (1) lack of thoroughness of method; (2) lack of proper spraying material, and (3) lack of knowledge of the exact life history of the moth.

The experiments demonstrated that this pest, the most important of all to the gruit grower of Colorado, may be conrolled by arsenical sprays applied properly and at the correct time.

The number of sprays required to control the moth in an orchard will depend principally upon (1) previous infestation of orchard; (2) proximity to other infested orchards; (3) efficiency of earlier sprays, and (4) variety of fruit.

To obtain results of greatest practical value to the fruit grower, orchard blocks of considerable size were chosen and given treatment in the most thoroughgoing and intelligent manner. Records of every detail were tabulated, and at the close of the season, in determining results, very large numbers of apples were given hand-to-hand inspection. For example, over 100,000 apples, representing upwards of 600 bushel boxes, were given a most critical examination to reveal, as nearly as possible, the exact outcome of the experiment.

Life History Studies—A study of the life history of the moth carried through the season showed many things of vital importance relating to the proper time to spray. No great variation or change of habit of the moth was noted. The time required for the passing of each stage of the insect was practically identical with other observations of the insect in the state. The time or dates of transformations of the moth were found, however, to be much earlier than for the majority of the other fruit sections of Colorado, and some variation exists between the different portions of the Grand Valley, transformations taking place earlier, as a rule, in the region about Palisade than in the country surrounding Grand Junction or Fruita.

Parasites—Natural parasites of the insect were studied, one of the most interesting being the minute bee, *Trichogramma pretiosa,* laying its eggs and developing within the tiny egg of the codling moth.

Bands—The use of bands is not discouraged, but they can not be depended upon alone to control the moth. If used, the old ones which have remained on the tree through the winter should be cleaned up by April 1st to prevent larvae from changing to pupae and moths making their escape. They should also be gone over at least every ten days through the summer until the middle or latter part of August, after which there will be little danger of moths emerging until the following spring.

Spraying Experiments—As stated, spraying with arsenicals was the standard remedy adopted, and the studies were made upon (1) Time to spray; (2) Kind of spray, and (3) Way to spray.

Time to Spray—The time to apply the first spray in the experiment conducted was determined by the condition of the calyx of the bloom, and that of the later sprays by careful and systematic observation for the appearance of the eggs of the moth.

Close observation of the calyx will determine when it is in an

ideal condition for spraying. This time should be following the dropping of the petals but before the closing of the calyx. A period not to exceed from five to seven days for any one variety would cover the time when this first spray should be applied. Sprayed too early or before the petals are fallen, bees about the bloom are in danger of being destroyed, and, sprayed too late, the green sepals will have come together at their tips, closing the calyx cup against all possibility of being filled with the poison.

The center blossoms are invariably the first to open their petals and first to drop them. They are first to close their calyces and most likely to set fruit which will remain without dropping from the tree. It is therefore evident that this first spraying should be done with these blossoms in mind. The first eggs do not appear for several weeks later. When the young larvæ hatch from these eggs, the larger per cent of them enter at the calyx, and if the first spraying has left the calyx containing a liberal amount of poison, their first meal will, in all probability, be their last. Sixty per cent or more of the first generation larvae, according to this summer's observations, entered at the calyx. For the remaining forty per cent or less entering at the side or stem end of the apple, a second spray must be applied early enough to coat the surface of the small apple with poison before the hatching larvae make their appearance, and this coating must be maintained upon the fruit until the first generation's eggs have hatched.

Other conditions being right, two sprayings with an adhesive arsenical will perform this end, and the first generation thus practically destroyed. There being but two full generations of the insect through the season, if the first be destroyed there should be no second left with which to contend.

As stated above, however, in common practice there will be cases where more than two sprays are necessary, and these additional ones should be directed against the second generation.

Any one may determine the proper time to spray by observations upon time of egg appearance, though in practice this is more or less difficult for the average orchardist.

The date of appearance of the blossoms upon fruit trees is dependent upon meteorological conditions for the spring. These same conditions regulate the initial appearance of the adult moth, and as its times for transformation are fairly constant thereafter, it seems possible that a general rule may be made for common use, based upon the blooming of the fruit in spring. Such a general rule is herewith presented, thought to be dependable, at least in the general locality wherein it was determined, and if conclusions above stated are correct, the rule should apply for other points as well. Observations upon the time of appearance of the insect in any of its stages could be made to supplement the general rule. The efficiency of the first two sprays suggested will largely determine the necessity of the later sprays. The dates given are those applying to the blooming and spraying of Jonathans at Fruita this year, and should be considered

as subject to variation with place, season, and variety. The egg observations were made upon trees receiving no treatment throughout the season.

HOW TIME TO SPRAY WAS DETERMINED IN EXPERIMENTAL ORCHARD.		TIME TO SPRAY—GENERAL RULE.
Petals dropped—calyces open	May 11	
First spray	May 11	(1.) Petals off-calyces open.
First eggs seen	May 21	
Numbers eggs seen	June 1	(2.) (*a*) One month from full bloom. (*b*) Three weeks from center calyces closing. (*c*) When apples are about ½ in. diameter.
Second spray	June 2	
First generation, eggs maximum	June 13–19	
First generation, eggs minimum	June 28	
Second generation, eggs begin	July 2	
Third spray—(suggested)	July 2	(3) One month from (2)
Second generation, eggs abundant	July 17	
Fourth spray—(suggested)	July 18	(4) Two weeks from (3)
Second generation, eggs maximum	July 25–31	
Fifth spray—(suggested)	August 1	(5) Two weeks from (4)
Second generation, eggs diminished to about	Sept. 1	

The time in which an orchard must be completed with the first spraying will be of greater importance than the time required for second or other later sprays. Power spraying outfits make it possible to cover larger orchards in less time than with hand apparatus, but it has been found that under ordinary conditions one good power outfit should not be expected to cover more than twenty acres of full-bearing orchard at the first codling moth spray.

In apple orchards of mixed varieties those blooming first should be sprayed first. Pears do not close their calyces as quickly as apples, and their first spraying may be longer delayed.

Kind of Spray—The experiments of the year demonstrated that Swift's arsenate of lead was slightly superior to the arsenite of lime so far as killing effect upon worms was concerned. The difference seemed to be less than 4 per cent, but though the cost of the lead is considerably more, it is probable that with a heavy yield of fruit of high market value the lead would probably more than pay for the difference in cost. It is more convenient and less liable to injure foliage. Other brands of arsenate of lead were used with nearly equal success in controlling the worms, but some samples had been improperly made and caused injury to foliage and fruit from an excess of free arsenic contained. Arsenite of lime, used with sufficient lime, will

cause no injury to trees under ordinary conditions, though it is more liable to do injury than properly made lead arsenate. Injury to trees from arsenical sprays is more or less dependent upon variety of fruit and meteorological conditions at time of or following spraying. A practice among some orchard men the past season in Mesa County has been to use arsenate of lead for the first and second sprays, and if further spraying is found necessary the cheaper arsenite of lime is substituted.

Arsenate of lead was used at the rate of 12 pounds paste per 200 gallons of water in the experimental orchard.

Arsenite of lime was used at the rate of 1 pound arsenic, 4 pounds sal soda, 30 pounds lime per 200 gallons of spray, the arsenic and sal soda being boiled together in a small quantity of water for fifteen minutes until dissolved, after which the lime slacked with water to form a milk was added.

Both arsenate of lead and the arsenite of lime sprays, from their white coating upon the leaves, produce a shading effect, which in our arid climate serves a secondary beneficial effect by reducing transpiration by the foliage.

Method or Way to Spray—In the experiments of the year it was shown that the method of application had more to do with success than a difference of the insecticides used. The variation between poor spraying and very good spraying might well vary between 20 per cent and 98 per cent, while, as shown, the two insecticides showed variation of only about 4 per cent.

For the 12-year-old apple trees in the experiment at Fruita, an average of 12.9 gallons of spray was applied per tree for the first spray, and 9.9 gallons were used for later ones.

For the early spraying a coarser spray of liquid, such as would be given by a Bordeaux nozzle or a coarse Vermorel nozzle cap, is desirable. At this spraying the tree should be drenched with a strong, driving, coarse spray. It should be directed straight into the calyx cups that a maximum amount of poison may be placed in position there. It was determined by actual count that at spraying time average apple trees had two-thirds of their blossoms pointing in an upward direction and one-third in a downward direction. It is, then, apparent that spray must be directed downward upon the tree as well as upward through the branches. It was found necessary with full-bearing trees, in order to insure thorough work, that spraying be directed downward from the top of a tower constructed over the spray wagon. Where power outfits are used, and where the rows are of such a distance apart that the inner halves of any two can be treated from a point midway, it will be found that on medium to large trees two men upon the tower and one man spraying upward from the ground will be found most satisfactory. Spray poles eight to twelve feet long should be used by both ground and tower men. In one of the experimental orchards the height of tower man's reach was twenty-five feet above the ground.

For the later sprays, a nozzle producing a fine mist is desirable. A nozzle of the double-vermorel type, arranged in such a way that the direction of the nozzle can be placed at any angle with the spray pole, is wanted. The size of aperture wanted in the nozzle cap will depend upon the pressure maintained. The higher pressures can be directed through larger apertures and still produce as fine a spray. Higher pressures economize upon material and time, and under ordinary conditions are most desirable.

In the experiment conducted upon the orchard of Mr. G. W. Marchant, of Fruita, two sprayings with Swift's arsenate of lead (12 pounds per 200 gallons) applied at the times indicated in the above table, and in a thorough manner, produced 98 per cent winesap, 95.6 Ben Davis, and 91.8 Jonathan apples free at picking time from all worm holes. Picked, unsprayed Jonathans in a block in the same orchard gave only 43.1 per cent free from worm holes, and 49 per cent of the apples, by actual count, originally borne by the trees, had fallen to the ground, 96 per cent wormy before picking. Only 15 per cent of the total crop of sprayed Jonathans fell to the ground as windfalls, and 74.1 of these were perfect apples. The apples in the sprayed plats were treated with a repetition spray following a heavy rain, though by comparison with plats left untreated with such spray it was found that the additional or repetition spray was unnecessary.

The complete details of this summer's experiments and observations upon the codling moth will be available in a special bulletin issued by the Colorado Agricultural Experiment Station, which bulletin is now under preparation.

HOWARD SCALE. (*Aspidiotus howardi Ckll.*)

This pest is one of greatest importance to the pear growers of parts of Colorado. Besides the pear, it is known to infest prune, plum, apple, almond, and certain shade and forest trees.

The life history of the insect was partially worked out during the year and experiments conducted showed the insect to be possible of cheap and complete control by spring applications of the lime and sulfur wash.

As a bulletin is also soon to be issued upon this pest and its remedies, based principally upon this season's investigations, details of the work on the insect may be ommitted in this general report.

PEACH TWIG-BORER. (*Anarsia lineatella* Zell.)

Introductory—Experiments conducted at Palisade have demonstrated the great value of arsenate of lead against the twig-borer of the peach, which caused considerable damage to the peaches in this and other localities of Western Colorado.

Former recommendations for the control of this insect have been for spring applications of lime and sulphur washes. This has in fact, been a most successful treatment, but the use of lead arsenate against the twig-borer of the peach is destined to meet with equal popularity when its efficiency, cost, and convenience of preparation and application are considered.

The peach twig-borer is one of the most important pests to the peach growers of Western Colorado. All of the peach spraying carried on in the Grand Valley the past spring was directed against either the peach aphis or the peach twig-borer.

It is estimated that this pest cost the peach growers of California over a million dollars in the four years following 1898. To the growers of Grand Valley it has cost much loss for some years past, and its distribution on the Western Slope of the state seems to be quite general wherever peaches are grown.

Life History and Injury—The injury is caused by a small pinkish brown worm, with black head, measuring, when fully grown, about one-half inch long. The worm is the larval or immature stage of a small greyish moth.

The winter is passed by the larvae, still very minute, in small chambers hollowed out within the spongy tissue of the bark at the crotches of small limbs. The chamber is lined with silk of the larva's secretion, and the only evidence of the presence of the chamber is in a very small and inconspicuous heap of frass or peach-wood dust standing outward from the mouth of the burrow. Early in the spring, at about the same time the foliage of the peach shows as small green tufts upon the twig tips, the larvae leave their burrows and attack the tender twigs, boring into them near their tips and down through their pitch, forming galleries from one-third to one and one-half inch in length.

Examinations of infested peach trees at Palisade last spring showed these bored twigs wilting and turning brown early in the month of May. Later in the season, twigs bearing half a dozen leaf tufts near their tips would have each bored and killed and from all appearances by the same larvae. This injury to the terminal twigs constitute an important injury to the tree. Young peach trees are usually worst infested, their growth being sometimes greatly retarded.

On the 18th of May a number of larvae were taken in peach twigs at Palisade and kept in water in a closed cage at my insectary. An examination of the cage May 24 showed that two of the larvae had already changed to brown chrysalids or pupae, both emerging on May 28.

On May 20 many larvae were also found concealed about the base of the tree at the surface of the earth and hiding about the bark, and it seems that at this date the majority of the larvae, which hibernated over winter in the small bark cavities, have now completed their feeding on the twigs and are descending for pupation. As stated, the usual habit of the first or hibernating brood of larvae is to burrow into the twigs. A few instances were found, however, where small peaches, still no larger than a pea, were burrowed into, leaving the fruit with a hollow cavity within.

The small second generation worms were seen beginning their work early in June. It is this generation which brings about another and by far the greater amount of injury to the peach crop. Larvae from this generation make their way directly into the forming peach

itself, and the "gummy" peach is the result. Projecting bits or masses of exuded gum appear on the surface, and from their appearance and impaired keeping qualities they are rendered unfit for market. Some peaches containing larvae of the twig-borer find their way into boxes to be marketed on account of having the borer deep in the peach or within the pit without external signs of habitation. Such fruit, however, is first to soften and decay, and should be excluded, if possible.

Control—At Grand Junction last spring I received many inquiries from peach growers as to the best measures of twig-borer control.

So far as published accounts were available, contact insecticides, such as kerosene emulsion or lime and sulfur wash, were the ones considered most effective. The previous spring Mr. Frank Berger, of Palisade, and a few other growers of that place, had used arsenate of lead as a spring spraying, instead of the lime and sulfur wash ordinarily used, and reported no injury from twig-borer following. As none of these orchards had portions left with no spray, I could not determine for certainty whether the favorable results reported by these orchardists was due to the effectiveness of the spray or to the lack of original infestation by the twig-borer.

To determine this it seemed necessary to prove the value of the arsenical spray by an experiment carried on in an orchard where a considrable portion was left untreated, which was done in the five-year-old peach orchard of ninety-two trees belonging to Mr. S. L. Carson, at Palisade, where a portion was sprayed with arsenate of lead, another with the lime and sulfur wash, and a third part left with no spray. The arsenate of lead was used at the rate of 5 pounds of the paste to 50 gallons of water. The lime and sulfur wash was used at the rate of 15 pounds lump lime and 15 pounds flowers of sulfur per 50 gallons of water, the two ingredients being boiled together in a small amount of water for forty-five minutes, then diluted with enough cold water to make fifty gallons of spray. The spraying was done with a hand pump and sprayed trees thoroughly coated over all bark and twig surface. The two sprays, as applied, were of about equal cost—each a trifle over 1 cent per gallon, exclusive of cost of preparation. The arsenate of lead spray was far less inconvenient, and was quicker in preparation, and was also more pleasant to prepare and apply.

The spraying was done on April 14, at which time the majority of the blossom buds showed their pink tips, but as a rule were unopened, with the essential parts of the blossom still concealed by the folded petals of the flower. Some varieties, however, in each plat were farther advanced and some with as many as 87 per cent of the blossoms open.

The comparative insecticidal values of the two sprays were apparent through the season from the number of injured twigs per tree, and also from the number of gummy peaches per tree occurring upon each plat.

A striking difference was apparent when the number of injured twigs per tree were brought into comparison by observations made in May and shown in the following table:

A COMPARISON BETWEEN LIME AND SULFUR WASH AND ARSENATE OF LEAD AGAINST PEACH TWIG-BORER.

Spray.	Date Sprayed.	No. trees sprayed.	No. trees examined.	Date examined.	Total No. injured twigs counted.	Average No. injured twigs per tree.	Per Cent. Benefit.	Conclusions.
Lime and Sulfur....	14 Apr.	38	17	9-18 My	72	4.23	90	Good.
Arsenate of Lead..	14 Apr.	35	16	"	20	1.25	97	Better.
Check	No spray	18	8	"	342	42 75	0	

Circumstances prevented the keeping of an exact record of the number of wormy peaches taken from each plat, but a very noticeable difference was noted at time of picking—a difference quite as marked and corresponding in results with the figures shown in the above table. In fact, the owner of the orchard invariably picked the wormy peaches from the plat not treated and found scarcely any fruit damaged in either of the plats sprayed.

It may be said that arsenate of lead, applied in the spring at the time the buds of the peach are beginning to open, will control the peach twig-borer as effectually and cheaply as the lime and sulfur wash, up to this time the most universally used.

Any arsenate of lead spray applied to peach trees must not contain free arsenic, as they are easily damaged by impure lead or lead diluted with water to contain too high a per cent of the poison, though pure. Growers using 3 pounds lead per 50 gallons water were equally successful, and from the susceptibility of peach to injury, this latter strength is recommended, instead of the stronger spray used in the experiment reported above.

PEACH-BORER. (*Sanninoidea exitiosa* Say.)

Distribution—This dangerous insect has been found present in some peach orchards of the Western Slope.

Our species is the same as the one found in Eastern states, causing such widespread damage to peach trees. It is evidently a pest which has come into the orchards along with nursery stock brought to us from some infested part of our country

Injury and Life History—The injury is one resulting from the burrowing of a yellowish-white larva, which, when fully grown, sometimes measures one and one-fourth inches in length. Signs of the presence of the borer are the gummy exudations coming from the crown of the tree at the top of the ground. Infested trees examined early in the summer showed larvae of sizes varying from one-fourth to one and one-fourth inches in length. Some small larvae were then barely concealed beneath the peach gum on the outer bark.

Other larger larvae were within extensive chambers. extending up and down through the wood. sometimes an inch beneath the bark. Trees badly infested are completely girdled and killed. The insects spend the winter as larvæ, and in the early summer change to pupæ within a brown cocoon or cell from seven-eighths to one inch long by one-fourth to five-sixteenths inch in diameter, usually projecting into or from the gummy mass at the base of the tree. The first pupa was found formed within these cocoons on the 15th of June, though the majority were being formed about the middle of July. The pupæ yield moths, the female of which are of a blackish-brown color, with partially transparent wings and a black body. circled at about the middle with a beautiful orange band. The males are smaller and more slender than the females and have a number of smaller, less conspicuous bands of yellow about the abdominal segments and with more nearly transparent wings. The first moths appeared on July 6, though the maximum number were not appearing until about August 11, a singular fact, since these moths are known to come out in greatest numbers in New York state and at Washington, D. C., from one and one-half to two months earlier in the season. Eggs are laid upon the rough bark about the crown of the tree. The eggs, when laid, are oval and of a brown color. Large numbers are deposited by each female. On August 6, a single female gave by dissection about 400 eggs, 250 of the number at that date being brownish in color and well formed, while 150 were white and still embryonic in nature.

Experiments Begun—Its importance made it seem advisable to test remedial measures, and various old and some new methods of combatting the pest were begun in June, and the final results are still pending.

Following are the measures under comparison in the experiment:

(1) Carbon bisulfide, 1 ounce per tree about crown.
(2) Tobacco dust, 2 pounds per tree about crown.
(3) Tarred felt and wire shields about base of tree.
(4) Lime dust, 2 pounds to 4 pounds per tree about base of tree.
(5) Dirt removed and larvæ removed by hand.
(6) Banking earth about tree's base.
(7) Tree washes.
(8) Trees not treated in same orchard to be used as comparison.

GREEN APHIS OF APPLE. (*Aphis pomi.*)

Importance—The unusual abundance of this aphid the past season upon apple and occasionally upon pear on the Western Slope has made it necessary to make observations upon and carry out insecticidal tests against it.

Life History—The green aphis winters as eggs upon the twigs of the tree, and the past spring a very large per cent withstood the winter. They began hatching about Grand Junction about April 1, continuing for two weeks or more. The young hatched at about the same time the first traces of green foliage appeared, and thus found tender food upon which to feed at once.

In the latter part of April winged insects appeared and a general spreading of the pest from tree to tree and orchard to orchard took place. Multiplication was enormously rapid. The injury continued to increase in severity through the summer. Lace wings and syrphus fly larvæ, as well as the adults and larvæ of lady beetles, served to do much good later in the season, but did not succeed in reducing the aphids enough to prevent great injury. Eggs of the green aphis were first found in the fall at Grand Junction on October 16. When first laid, the eggs are green, but finally turn to a glistening black.

Injury—They have been a great hindrance to the growth of young apple trees set the past spring or the preceding year, and older trees have not been exempt from their attacks. Missouri Pippin apples of all ages have suffered heavily, the aphis apparently preferring this variety to any other common in the Valley of the Grand. Badly infested trees through the summer present a most disgusting appearance, the aphids becoming so numerous that the whole tree assumes a sticky coating of the secretion from the bodies of the insect. This "honey dew" secretion attracts swarms of flies and ants, and the trees often emit a very disagreeable odor.

The effect upon the tree, if young, is a severe retarding of its growth. A form of injury noted this season, thought to be due to this insect, was an odd and greatly deformed growth of the fruit itself. Nero and Winesap apples were found affected in this way. The young apples, when only from one-fourth to one-half inch in diameter, had been so thickly covered with aphids that their growth had been suddenly checked. Later on, their growth had been resumed principally from the outer end of the apple, producing what might be called a "double apple," with a constriction at the middle point. Other apples were caused to grow in greatly gnarled or knotted forms. All were greatly dwarfed in size, seventeen Winesap apples at harvest time being contained, in one instance, within a common match box.

Treatment—Trees heavily infested had their leaves tightly curled, due to the presence of myriads of the aphids upon their under surfaces. With the aphids thus concealed within the curled leaves, it was found almost impossible to cover their bodies with any contact spray applied, and the practice of summer spraying against them was anything but a success. Individual trees were, in cases, cleared up, but other trees near by and left untreated usually very soon reinfested them.

Spring and early winter treatments were also carried out in experiments against this insect.

The spring spraying was directed against the eggs of the pest and gave the best promise of its successful control. In an experiment with a number of contact sprays applied April 5, just after the eggs had begun to hatch, it was found that the lime and sulfur wash proved the most successful. In this instance, 15 pounds of lime and 15 pounds of sulfur per 50 gallons of water were used, and practically all of the eggs and hatched aphids were destroyed.

In December, kerosene emulsion and soluble petroleum sprays were given egg-covered trees, and the per cent of eggs destroyed at time of hatching this spring will be determined. Further experiments for the control of this pest are planned, including a large series on contact insecticides to be used this spring.

WOOLLY APHIS. (*Schizoneura lanigera.*)

Importance—Probably more important to the fruit growers of Western Colorado than the green aphis is the woolly aphis of the apple. The past season this pest has ranked second only to the codling moth in destructiveness in the Grand Valley, and has been of first importance in other counties of the Western Slope.

Life History—Many lived through the winter upon the roots of the apples, and a few survived the winter upon the branches above ground. During the winter of 1905-06 the temperature at Grand Junction, according to the United States Weather Station, did not drop as low as the zero point, and the unusually mild winter perhaps had much to do in the great abundance of the insect this past summer.

In May many of the aphids above ground had already secreted their woolly coverings of white, and in cases heavily infested the water sprouts about the base of the tree. By the month of July, countless myriads of them were to be seen crawling over all parts of the tree and fruit, as well as upon the ground through the orchards. Winged ones were noted first at Fruita September 6.

Parasites—Parasites have done some service in helping to keep in control the pest, but have not been abundant enough to reduce the number of insects to a point below injury. Lace wing and syrphus-fly larvæ, as well as adults and larvæ of lady beetles, have been most prominent in preying upon this aphis. Some observations upon the habits and life history of these parasites have been made.

Injury—Roots and tops were attacked throughout the season, the twigs being sometimes entirely coated with the woolly secretion covering the bodies of the insects. Such infested twigs were greatly dwarfed, the bark on the twigs caused to split and grow in a gnarled and misshapen form. The "honey dew" secretion from the insects in some cases coated over the peeling of the fruit itself, leaving the surface so sticky and discolored that apples were disgusting in appearance and most unpleasant to handle. Grafts and top-worked trees suffered most heavily in the spring, and their injury continued through the summer.

So thick were the insects upon the branches that apple pickers working in the trees had their clothing covered with crushed bodies and the white secretion of the insect.

Roots about the crown of the trees were gnarled and knotted, resulting in the dwarfing of the trees, the production of undersized fruit, and, in exaggerated cases, the outright destruction of the trees themselves.

Experiments in Progress—Summer sprays, as with the green aphis, where the infestation was so severe and so general through the orchards, proved of small practical value.

This pest is of such importance that careful and exhaustive experiments of measures of control must be carried out against them without delay. In the fall and early winter a long list of insecticides were applied to infested trees, and the list will be duplicated this coming spring, and it is hoped that by the coming fall some practical suggestions upon an effective method of control of the pest may be reported. Tobacco and carbon bisulfide upon the roots of the trees, and kerosene emulsion, whale oil soap, and tobacco decoction sprayed upon the tree have been the previous practices of treatment by orchardmen. These measures, soluble petroleum sprays, tree tanglefoot bands and many other methods of control will be given thorough trial.

A NEW INJURY TO PEAR AND APPLE BUDS.

Description—On the 4th of May, an injury to buds of pear on grafts placed into pear stocks about one month earlier was observed. Attention to the injury had been called by the owner of the grafted trees, who had observed that his grafts, which should have been starting readily off into growth, were being held back by some insect, which apparently was eating away the buds as soon as they started to grow.

Examination on May 4 showed the injury to be caused by a tiny chrysomelid beetle (*Myochrous squamosus* LeC.) greyish-brown in color and less than one-fourth inch long. No published accounts of injuries of this kind from this beetle have been found, and it is probable that this observation of injury is the first recorded against the beetle. It caused enough trouble, however, to require some remdial measures. Unless something had been done greater damage would have resulted, and, as it was, some of the attacked grafts were destroyed by having all buds eaten away.

The beetles were discovered about the bases of the grafted pear trees, hiding beneath clods and in crevices of the earth. The principal injury was done to pear buds, though specimens were also taken feeding upon the buds of apple borne by twigs near the ground. Beetles were also found beneath clods about the apples. Not only did the beetles attack the buds upon grafts, but they were found eating into the pear leaf and fruit buds high up into the tree. In one instance, a beetle was watched eating away the petals of an open pear blossom. Search was made about the trees for a weed or plant which could have served as a natural food plant for either adult or larvæ, but none was found. As many as a dozen beetles were, in cases, collected about the grafts of a single small tree or about the base of the tree. The injury continued through the month of May, and beetles kept in cages at my insectary were kept alive through the month of June. Many of the beetles were found floating on the water in irrigating ditches late in May, and later adults were taken hiding beneath bands placed upon trees to capture codling moth larvæ.

Control—Several measures of control were suggested or used. A spray of arsenate of lead applied to the buds was tried and thought to have been of considerable benefit. The owner of the orchard prac-

ticed hand picking of the beetles, but the process would be entirely impracticable upon any number of trees. The winged beetle appeared to be more of a crawling insect than a flying one, which suggested the possibility of protecting young grafts by placing bands of "Tree Tanglefoot" or other adhesive bands about the tree trunks to keep the beetles from ascending in the spring.

MISCELLANEOUS OBSERVATIONS.

A great many other injuries to fruit or field crops by insects, rodents, etc., were observed through the season.

A pink-bodied aphis of undetermined species was found doing considerable damage to peach buds, blossoms, and young fruit early in the spring. Specimens were first seen April 13, at which time peaches were showing first bloom. The larger, flat-bodied, pinkish aphis first observed gives birth to young, which cluster about the blossoms and about the forming peaches, still very small, sucking from them the sap and causing many to fall to the ground. Later in the season, peach leaves are curled up by the aphids, but all seem to disappear late in May. The injury is thus done early in the season at the time fruit is setting. Application of the lime and sulfur wash just before the buds open is suggested as a means of control, and this and other measures of treatment will be tried in an experimental way the coming spring.

Observations were also made upon aphids infesting plums, elms, and poplar.

Injuries to cantaloupes were noted, caused by leaf miners, the common red ant of the prairies, and prairie dogs. In some orchards the green fruit worm caused injury to from 10 to 25 per cent of the young forming apples, but in orchards receiving proper codling moth spraying the injury is much less severe or reduced beneath notice.

A pear leaf blister mite, probably of a different species from that causing the injury in Eastern States, was observed in great numbers through the summer, causing the blackened curling of the pear leaves at the tip of the twigs, as well as producing minute blisters upon the leaves and causing them to drop from the trees prematurely. It is thought that a late spring spray with the lime and sulfur wash will also control this pest.

Other orchard pests observed, studied, or experimented upon in attempt at control were the buffalo tree hopper, tent caterpillar, hawk moth larvæ, grasshoppers, thrips, brown mite, pear and cherry slug, terrapin scale, Putnam scale, and numerous parasitic or predaceous insects doing beneficial service in the orchards.

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The Howard Scale

—BY—

ESTES P. TAYLOR

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THE HOWARD SCALE.

Aspidiotus howardi Ckll.

——BY——

ESTES P. TAYLOR.

INTRODUCTION.

The extensive injury wrought in parts of the State of Colorado to pear, prune, plum and other fruit and shade trees by this insect makes it one of especial interest to the horticultural industry at this particular time. Further, the pest is the nearest ally of San Jose or Chinese Scale, well known as the most destructive of all fruit tree enemies.* The Howard Scale is one of peculiar importance to fruit growers of this state since its first discovery was made in Colorado and fruit growers of no other state as yet consider the pest with the same degree of interest. So far as is known, two states only, Colorado and New Mexico, harbor this insect.

The history of the insect is all of comparatively recent date. It was first discovered by Prof. C. P. Gillette at Canon City, on August 31, 1894, upon the fruit and bark of prune and wild plum. These first specimens were sent to Dr. L. O. Howard of the Bureau of Entomology, U. S. Department of Agriculture and to Prof. T. D. A. Cockerell, then of the New Mexico Agricultural Experiment Station, but now of the State University of Colorado at Boulder. Dr. Howard pronounced the insect a new species and Professor Cockerell applied to it the name Howard scale.*

Professor Cockerell later encountered the scale at Albuquerque, New Mexico, in August, 1895, upon the fruit of silver prune which determination was verified by Mr. Pergande of the U. S. Department of Agriculture, from material furnished him.

The next published mention of it is from Professor Gillette in the Annual Report of the Experiment Station for 1901 when he reported its occurrence for the first time upon fruit trees of the Western Slope. Mr. H. E. Mathews, horticultural inspector for Delta county had, during that season, sent specimens of the scale taken from pear and

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*A most exhaustive and complete treatise on "The San Jose or Chinese Scale" has recently been issued by Mr. C. L. Marlatt as Bulletin No. 62, Bureau of Entomology, U. S. Dept. of Agriculture. This bulletin should be in the hands of every Colorado fruit grower. It may be had by application to the U. S. Dept. of Agriculture, Washington, D. C.

*The original description was published in Canadian Entomologist, XXVII p. 16 (1895). Prof. Wilmon Newell published, in 1899, from Iowa, Contributions from Dept. of Zoology and Entomology, No. 3 Iowa State College, an article upon "The North American Species of the Sub-genera ***Diaspidiotus*** and ***Hemiberlisia*** of the genus ***Aspidtous***" including Prof. Cockerell's original description of ***A. howardi*** Ckll. and giving as its habitat Colorado and New Mexico. More recently it has been given position in "Tables for the Identification of Rocky Mountain Coccidae" (scale insects and mealy bugs), published by Prof. Cockerell.

plum trees severely attacked. In the report for 1902 Professor Gillette reported his discovery of it upon the leaves of white ash trees in Denver.

Though the insect has been previously reported in various entomological publications, and notes have been given upon habits and portions of its life history, nothing, up to the present bulletin, has been published upon its control.

In Mesa county the Howard scale was found, by the writer, to be doing much damage. It was found in practically all localities where its food plants were known and at elevations above sea level varying from something over 4,000 feet to nearly 7,000 feet. Dr. S. M. Bradbury, horticultural inspector for Mesa county, reports that what he has taken to be Howard Scale has been known in the Grand Valley as a pest upon pears and other fruits since they were first grown here. In many instances fruit growers observing the infestation of their trees by a scale insect had suspected the presence of San Jose scale, while others supposed it to be the Putnam scale common in other states upon certain shade and fruit trees.

The fruit growers and fruit growers' associations of the Grand valley have given hearty co-operation in offering their orchards and materials for experimentation and otherwise aiding in bringing new data to light. Also acknowledgements are due members of the Bureau of Entomology at Washington for cuts furnished and determinations made; to Miss Miriam A. Palmer, entomological artist, of the Experiment Station for original drawings of the insect, and to Professor Gillette for valuable suggestions and much special assistance given.

FOOD PLANTS.

Notwithstanding the occurrence of this insect upon shade as well as fruit trees it is primarily an economic pest of the latter. In my observations it has been taken upon the following fruit trees: pear, prune, plum, almond, apple and peach. By far the greatest injury has been done to pear and by many orchardists it is popularly called the "pear scale."

Bartlett pears seem to be most commonly infested of varieties grown in Colorado. Certain varieties of fruit will often become heavily infested and require spraying long before sorts more nearly immune show any noticeable number of the scales.

Next to the pear, the prunes and plums seem to be the most susceptible. It seems that Wild Goose and other varieties of American plums show infestation more generally than the Japanese varieties. Silver prune trees are often found encrusted. Almonds, though grown to a limited extent in Western Colorado, seem to be quite susceptible to its ravages.

It is rather the exception than the rule to find apples attacked. A singular preference is shown, however, for the Grimes Golden. Scores of instances have been noted where trees of this variety show infestation and other varieties growing near by are totally exempt.

Slight infestation has also been found upon Bailey Sweet, White Winter Pippin, Snow and Jeneton.

Peach trees are practically exempt, probably only becoming slightly infested when standing very close to other varieties which are more commonly attacked. This is of rare occurrence, peaches and most varieties of apples being practically uninjured by the insect—a singular fact in consideration that the San Jose scale is most destructive to peaches and apples. Numerous cases are known of its existence upon native plum trees growing in the state. Of the shade trees reported infested, we have the white ash and the maple, the latter reported by Professor Cockerell.

From its appearance only in the two states named it seems probable that it originally lived upon native trees or plants and found suitable food upon the fruit trees planted adjacent to them in recent years.

NATURE OF DAMAGE.

Injuries from this insect are seen in the dwarfing of the trees robbed of their sap. cracking the bark, killing the tree outright, and in an unsightly pitting of the surface of the fruit with discoloration about the points of scale attachment. Upon the greener portion of the pears, the side shaded during growth, this reddening is more noticeable than upon the sun-exposed side. Some of the pits or indentures contain single scales and some bear clusters of several. In the case of yellow-skinned plums these reddened blotches about the scale are most noticeable and objectionable. With dark colored plums, prunes and pears, the scales appear as many small white specks scattered over the surface (plate I, fig. V). With the pear, deep pits are also found in the skin, with Bartletts some of these measure nearly one-fourth inch deep and as wide across at the top. (See plate I, figs. V. and VI). More often the scales are grouped into clusters about the calyx or stem end of the fruit. All fruit so injured is excluded from the fancy grades and placed in the cheaper ones if not rejected entirely.

Early descriptions of the insect gave it as a pest principally upon the fruit instead of the tree. The tendency to infest the fruit is perhaps greater than with other closely related scale insects, but the attack is also directed to bark, twigs and leaves. A marked tendency is shown for the insects to crowd outward to the tips of the branches where the bark is more easily pierced by them or where more succulent and tender tissue such as leaves or fruit is available.

When the twigs become heavily infested with the scales they may almost hide the bark as shown in the prune twig in plate I, fig. IV. If allowed to go unchecked upon trees most susceptible to their attack, the result will be a complete coating over the bark with an incrustation of the bodies of the insects and their scale secretions. Trees allowed to remain in this condition might be completely killed, and would bear only scale-covered fruit and leaves. The fruit would be quite unmarketable and the leaves, browned and impoverished by their sap sucking

parasites, would drop from the trees prematurely. Before spraying became generally adopted in the Grand Valley, the products of whole pear orchards were rendered unmarketable.

DESCRIPTION AND LIFE HISTORY.

This scale belongs to that class of insects receiving their food by sucking the juices of the plants to which they are attached. Having no mouth parts with which to chew their food, stomach poisons or arsenical sprays are without value applied to them. They must be controlled by contact sprays. They are of minute size and many times when but moderately abundant upon trees escape notice except by the trained observer. Every fruit grower should acquaint himself with the appearance of the pest and, if possible, be able to distinguish it from its nearest relatives. This will not always be possible for the average orchardist and it will be advisable to send samples of scale insects found upon the trees to the entomologist of the Agricultural Experiment Station, for determination. This should be done to avoid the mistake of maintaining more dangerous forms of insects which might be introduced by chance. The figures of Plate 2 show the insect drawn from life, but enlarged, represent its various stages, details of structure and general appearance and will aid in the determination of the species.

The male is the only form bearing wings and it is winged only upon becoming adult. All females and the males throughout the greater part of the year spend their lives attached and immovable upon the bark, leaves or fruit and it is during this time that the damage to the host plant is done. It is during this period of their lives that the hard, scaly coating forms over them as a protecting covering. The scales are secretions from the body of the insect concealed beneath. A short period is spent by both sexes crawling over the surface of the tree or its fruit before settling down for feeding. This period ,of but a few days duration at most, follows the hatching of the young from eggs deposited beneath the scales. At this time the very minute insects are scattered over the infested bark, appearing to the naked eye as mere specks of yellow orange dust. They are much smaller than newly born young San Jose scale. For so small an insect they are very active. One under observation traversed a distance of one-half inch in one minute. When it finally settles down it inserts its beak through the epidermis of the plant and, if a female, from that time to its death does not move. If a male, it remains stationary through its development to the adult and then equipped with wings, comes out from beneath its covering for the fertilization of the full grown females still beneath their scales.

When first attaching itself to the bark the secretion of the scaly covering commences. The newly settled individuals appear as very small white specks, as at that time the white fibers of the secretion have not yet become matted together nor assumed the darker hues. The female scale in developing assumes a circular outline and lies slightly convex upon the surface. Individually when matured, it is of a pale

grayish color, much lighter than the partially matured or even fully grown female of San Jose scale. The female insect when fully grown is, in diameter ,considerably less than the head of a common pin. She is orange-yellow in color, and broadly pyriform or pear-shaped. It is only through a higher power of the microscope that the characteristic markings at the tip of the abdomen (Plate 2, figs. I and II), distinguishing this insect from such close relatives as the Putman or San Jose scales, can be observed. The male scales are more elongate than the female scales, being oval in outline and often much darker in color. The male insects when fully grown and emerged are winged, of very minute size, and pale yellowish brown in color with black eyes which show plainly in the developing pupa while still beneath the scale.

The chief difference in the general appearance of Howard scale from its nearest allies is in the distinct pallidness of many of the scales.*

Badly infested trees have a grayish appearance over their bark much as if a layer of ashes covered the tree. When rubbed, this gives the surface a greasy or buttery appearance caused by the crushing of the bodies of myriads of the yellowish parasites which had been secreted beneath their grayish armors. Orchardists should be able to detect their presence long before the infestation has reached this stage. At first appearance, individual scales upon the bark will exhibit only inconspicuous grayish dots. If upon the branches of the apple, these dots will be surrounded by reddened areas in the bark, which will be noticed before the insect is seen. If upon the twigs of fruit trees other than apple these reddened blotches in the bark will be less noticeable.

The winter is spent as immature insects. On March 19, in the spring of 1906, some female scales were found well grown and pale gray to dark brown in color. Others among these were smaller in size, some circular and some oval in outline. All smaller sized scales near their centers showed a whitish area, in some cases dusky gray. In the center of the white area which occupied about one-third of the surface of the scale covering, a small whitish nipple was seen surrounded by a rather shallow or indistinct furrow or ring. Both ring and nipple were much less conspicuous than in the case of San Jose scale at this stage. On account of the weathering, most of them showed their summits as smooth or bald areas reddish or orange in color. The oval male scales were found to yield adults as early as April

*The original description of the insect as published by Prof. Cockerell in Can. Ent. XXVII p. 16, 1895, is as follows:

Aspidiotus howardi n. sp.—Female scale, circular, flat, about 1½ mm. diam., pale grayish with a slight reddish tinge; exuviae sublateral, covered, dull orange secretion over exuvie easily rubbed off.

Female broadly pyriform, orange; margin of terminal portion thickened, very finely striate showing a violet color in some lights. Plates spine-like, sparingly branched. Median lobes very large and prominent, close together but not contiguous, obliquely truncate, slightly crenate. Second pair of lobes small, broad and low. Third pair practically obsolete. There are conspicuous wax ducts. See Plate 2, Fig. 1a.

3 in the orchard, at which time several winged specimens were seen in process of fertilizing the matured females. Examination of infested trees at Grand Junction, February 9, 1907, showed the male larvae beneath the scales already with their black eyes apparent. No pupae were yet formed. Material taken indoors upon twigs has yielded males as early as February 22. The males seemingly emerge throughout the greater part of the summer.

Early in June many newly hatched insects of both sexes were beginning to crawl actively over the bark. By June 9 many had settled down, thickly covering the bark with the early summer brood. Some were upon the small pears also and others were seen upon the upper and lower leaf surfaces. Many at this date had well developed scale coverings already secreted over them. Oval eggs, pale yellow and with blunt ends, were found,showing the females to be oviparous rather than viviparous as in the case of the San Jose scale. The exact time required for hatching is evidently short for through the summer are usually to be seen from one to a dozen minute yellowish-orange colored and newly hatched young beneath each of these scale coverings along with small clusters of eggs. In cases, no eggs but only clusters of the very minute young, are to be found beneath the female scales and it has been suggested by Professor Gillette that they are occasionally born living.

In Western Colorado it is probable that at least three and perhaps four generations are developed during the season, including those living through the winter in an immature stage. These generations, however, greatly overlap one another making a continuous succession of individuals appearing throughout the season.

MEANS OF DISTRIBUTION.

The most common method of distribution of scale insects over long distances is well known to result from the shipment of infested nursery stock. Since almost all of the new orchard plantings within the state are of nursery stock from states free from this pest, and as little nursery stock is shipped away at present, this phase of the question does not appear to be of any particular consequence.

The local transmission of the insect is largely dependent upon outside forces as the only time during which the female has power of locomotion is for the short period from its hatching beneath the scale covering to the time it settles down to feed at a fixed point upon the plant. This interval of activity is, however, of short duration and no great distance can be traversed in the time by so small an insect. Except for dispersal over single trees the insect must depend upon outside agencies in spreading. Such agencies are the wind, other crawling and flying insects upon the trees, as ants and lady beetles, birds and chickens or live stock at large in orchards. Irrigation ditches evidently transport the minute active individuals which have been blown or washed from infested trees. It is also likely that the common operations of the orchard, such as cultivation,

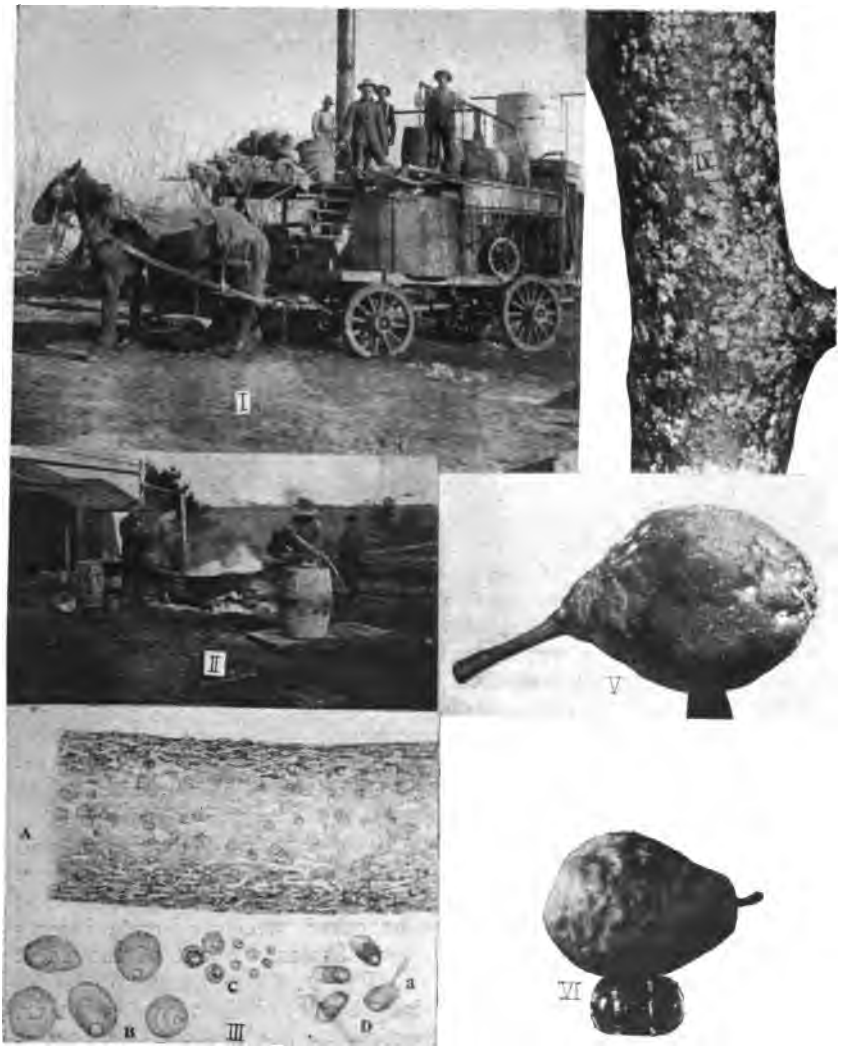

PLATE I

pruning and picking of fruit serve, to some extent, to carry the movable ones from one tree to another.

The effect of an infested orchard in infesting surrounding orchards is one of the most serious phases of the problem. On account of this scale spreading so slowly, it is noteworthy that well directed efforts of control are likely to be followed by quicker and more lasting results than when orchardists wage warfare against more active insects.

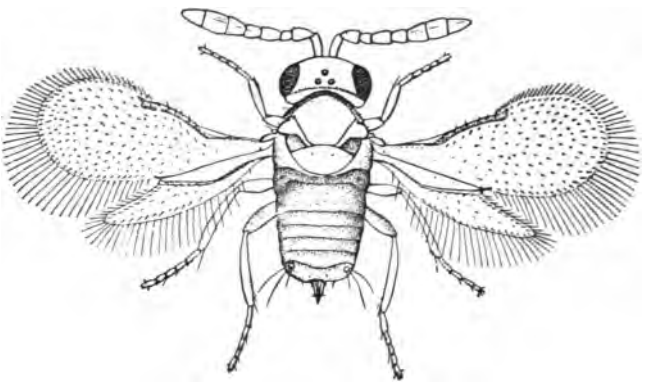

FIGURE 1

Howard scale parasite, ***Prospalta anrantii*** How., greatly enlarged. After L. O. Howard, Bur. of Ent., Washington, D. C.

NATURAL ENEMIES.

In a count made upon badly infested pear trees March 19, 1906, of a large number of scales, about 31 per cent contained no living insect. This did not, however, correctly represent the natural mortality of the insects due to weathering. Some of the dead scales resulted from parasitic or predatory insects.

Early in June and again in the month of August adults of an interesting little bee parasite were observed. Specimens were determined as *Prospalta aurantii* How., and the observation according to Dr. L. O. Howard is the first record of the parasite infesting this insect. The minute bee develops within the body of the insect and eats a small round hole through the scale where it makes its escape. Dr. Howard reports that this parasitic bee has been reared from San Jose scale and is effective against nine other species of scale insects common in different parts of the United States. A cut of the adult parasite is shown, greatly enlarged, in Fig. 1.

Adult and larvae of a common lady beetle, *Chilocorus bivulnerus,* also played some part in the destruction of the scale. The beetles winter as adults and have been seen as early as February crawling over the bark performing their useful work. Adults of the beetle have shiny black outer wings each bearing a beautiful spot of red. The beetle in its various stages is shown in Fig 2.

Last summer small spiders were observed destroying the newly hatched scale insects upon infested pear trees. Webs spun across the

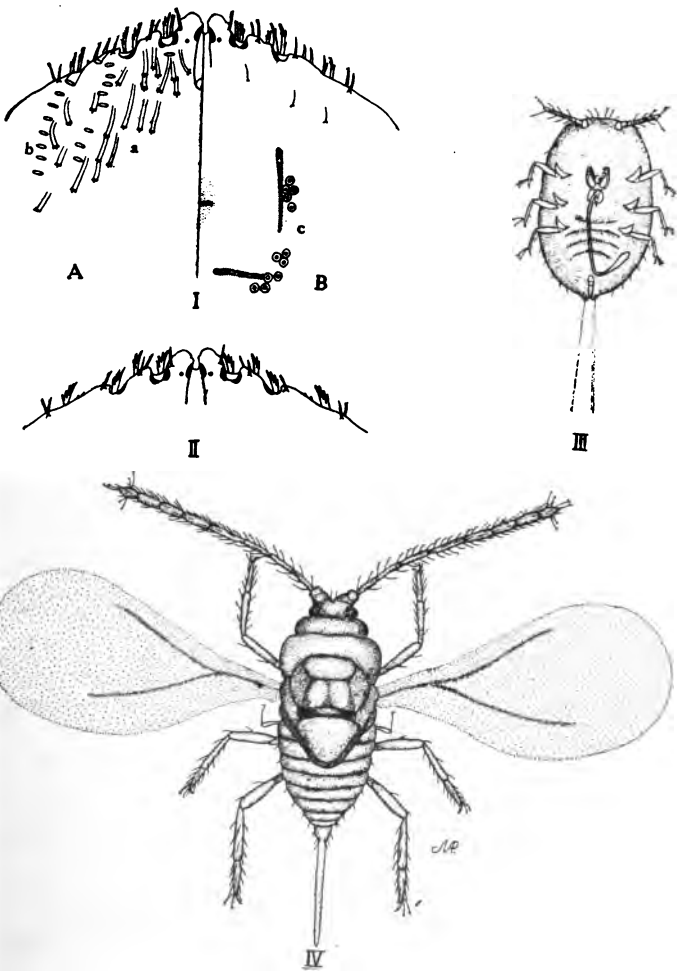

PLATE II

calyx end of pears were found filled with the wings and remains of male scale insects which had been entrapped and destroyed. Unprotected female insects were also found to have formed a portion of the spider's food, though those protected by scales were apparently unmolested.

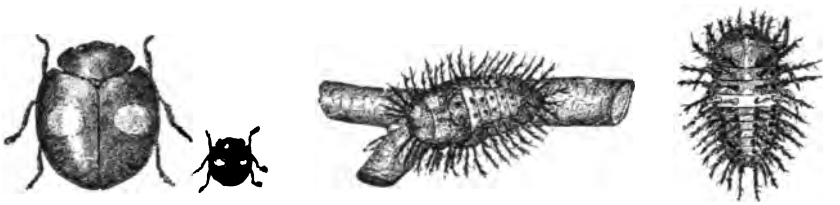

FIGURE 2

Twice-stabbed lady-beetle, *Chilocorus bivulnerus*, larva, pupa and adult natural size. After Bureau of Entomology, Washington, D. C.

Natural enemies, though very useful, do not usually succeed in reducing this pest to a degree making spraying unnecessary.

REMEDIES.

EXPERIMENTS IN MESA COUNTY.—The first spraying against this insect in Mesa county, according to the statements of local fruit growers, was about six years ago when the finding of "scaly" fruit called the attention of the growers to the necessity of steps toward control. The first material used seems to have been sprays of whale oil soap. These sprays, though expensive and inconvenient, proved fairly efficient in the hands of growers thorough in their methods and careful in preparing the mixture. At the time of the writer's first examination of pear orchards in the Grand Valley many were found which had been most successfully treated with the lime-sulfur-salt spray. Great variety of opinion existed regarding the method of preparation, the proper formulas and the best way and time in which to apply the spray. Sufficient difference of opinion existed to make spraying experiments advisable.

Accordingly the pear orchard of Mr. Ray D. Garrison, east of Grand Junction, well suited to the experiment was selected and given treatment with the permission and co-operation of the owner.

The orchard consisted of about 200 medium sized trees, of Bartlett, Clapp's Favorite, P. de Esta, Buerre de Anjou and Flemish Beauty varieties, the last being largely left untreated the previous year and now thickly covered by the scale. The spraying was done April 3, 5 and 6, 1906, just before the opening of the fruit buds, and a thorough coating was given to all parts of the tree. Upon all plats spraying was done with the same degree of thoroughness. The insecticides used were variations of the lime and sulfur washes, kerosene-lime emulsion prepared by combining kerosene with lime, and scalecide.

Scalecide is an oil treated chemically so that it may be mixed with cold water without separation. It is a commercial product and is sim-

ple to prepare for spraying. It requires no special manipulation and is pleasant to apply. Scalecide was sprayed upon trees in another orchard and gave most promising results. The kerosene-lime emulsion proved a failure, as too great difficulty was encountered in mixing the materials.

The lime and sulfur sprays were, from all standpoints, most satisfactory. They were used in the experiment as follows:

(1) Rex lime and sulfur, diluted 1 to 11 with cold water.

(2) Rex lime and sulful, diluted 1 to 8 with cold water and 15 pounds lime added per 50 gallons spray.

(3) Lime-sulfur-soda wash prepared without use of external heat and boiled by the soda and heat of the slaking lime. Thirty pounds lump lime, 15 pounds sulfur and 5 pounds caustic soda per 50 gallons water were used.

(4) Lime-sulfur wash prepared in the usual way by boiling 45 minutes with external heat and composed of 15 pounds lime, 15 pounds sulfur per 50 gallons water.

A portion of the trees were left unsprayed for comparison. Before spraying, counts were made which showed 69 per cent of the lice living and 31 per cent dead from natural causes.

These comparisons for all plats are shown in the following table:

LIME-SULFUR WASHES AGAINST HOWARD SCALE ON PEAR.

Spray	Formula	Cost per 200 gallons spray	Date Spray'd	Scales on bark Apr. 25 Per cent dead	Scales on pears Aug. 17 Per cent pears pit'd
Commercial Rex Lime-Sulfur	Rex, 1 gallon Water, 11 gallons	$4.15	3-5 Apr.	74.9	−1.0
do.	Rex, 1 gallon Water, 8 gallons Lime, 2¼ pounds	$5.70	6 Apr.	85.2	2.8
Self-boiled Lime-sulfur soda	Lime, 30 pounds Sulfur, 15 " Caustic Soda, 5 lb Water, 50 gallons	$3.45	6 Apr.	95.6	1.0
Lime-sulfur Boiled	Lime, 15 pounds Sulfur, 15 pounds Water, 50 gallons Boiled 45 min.	$2.00	5 Apr.	93.8	0.6
Check	Not Sprayed			48.0	96.1

The above spraying observations were made upon both treated and check trees throughout the season. Two means of comparison

indicated the results. The first was that shown in a count made April 25, of living and dead insects upon the bark; and the second, of more practical interest, a comparison shown by a count on August 17, at the time of the last harvest, of the number of pears showing pits upon their surfaces.

COMMERCIAL REX MIXTURE.

Rex is a concentrated lime and sulphur mixture prepared by boiling together the two ingredients until combined and removing for use only the clear, reddish liquid free from sediment. It is a product prepared and sold by Rex Stock Food Co., of Omaha, Neb. It has been formerly used as a stock dip in the West. For spraying, it has only to be diluted with cold water. Lime may be added if desired. The lime is added so that a white coating may be left upon the tree indicating where parts have been completely covered, and to hold the spray temporarily upon the surface, causing more of the mixture to dry and adhere than would do so if applied as a clear liquid.

Referring to the preceding table, it will be seen that both strengths were effective in reducing the number of scales upon the trees so that injury to the fruit was prevented. The slight difference in their effectiveness may be practically overlooked when these two results are compare with the 96.1 per cent of fruit rendered unfit for market upon the unsprayed trees. Some of the infested pears, unsprayed, bore at picking time no less than 328 attached scales of varying sizes.

The scales dead upon the tree on April 25, twenty days after spraying, was 85.2 per cent upon the Rex of stronger dilution, and 74.9 per cent dead upon trees sprayed with the weaker mixture. The action of all lime-sulphur sprays is continued for a considerable time after spraying. The former figure represents the increased effectiveness produced by an increase in strength and the addition of milk of lime. Both may be classed as of value in comparison with the 48 per cent dead upon the check. It will be remembered 31 per cent of the scales indicated by count were dead at the beginning of the experiment and the per cent scales dead as counted upon April 25 on sprayed plats included the 31 per cent shown to be dead from natural causes without treatment. The per cents given, therefore, under estimate the ratio of benefit actually derived from the sprays.

In summing up it may be said that Rex lime-sulphur diluted one to eight with cold water with lime added as per formula is an effective spray against the Howard scale. It is not recommended as more effective than the standard orchard-boiled lime and sulphur washes. As was shown by experiment, the latter were slightly more effective than the Rex even when used at the stronger strength, but the ease and convenience of preparation of the Rex recommends it to the use of orchardists not fitted with the appliances for boiling their own spray. Some growers prefer to pay more for material and save the time and labor of preparing their own mixture. Examination of the scales shows them more loosely attached to the bark than is the San Jose scale, thus affording less resistance to the spray in coming in contact with the body of the insect.

In the spring of 1906, in the orchard section of the Grand valley, a carload of 30,000 pounds of Rex was used experimentally as a spray principally against this insect, and in the spring of 1907 five car loads were shipped into the above section for use against this and other orchard pests. Upon Howard scale results have been satisfactory.

The spray has the disadvantage, as a commercial product, of being subject to variation in strength without knowledge of the consumer. The orchardist compounding his own spray material may feel more confident of his product.

The Rex mixture was to be had the past season by growers at Grand Junction for 25 cents per gallon, making the cost of 200 gallons of spray of the recommended formula about $5.70, or a trifle less than 3 cents per gallon.

LIME AND SULFUR MIXTURES. The lime and sulfur wash mixed in the right proportions, properly boiled and correctly sprayed is the most satisfactory spray thus far used against Howard scale.

Lime and sulfur was originally a stock dip used in California and was first demonstrated to be of value as an insecticide in 1886.* It was then taken up as a scale treatment in the East and is now very widely used and considered the standard scale remedy. It is also valuable as a dormant tree spray against many other insects and is of known fungicidal value, controlling the peach leaf curl of some states.

Different formulas have been adopted in different states. Some recommend slightly more lime than sulfur in order to insure the combining of all sulfur. Others contend that equal parts of lime and sulfur are best when a strong quick lime, high in calcium, is used. The belief that equal portions of lime and sulfur, as a rule, produce as strong a solution, chemically, as is possible to secure, is endorsed in a recent bulletin by J. R. Haywood of the Bureau of Chemistry.* The addition of salt formerly recommended may be safely discontinued. It adds nothing to the killing effect of the spray, increases cost, makes the spray more unpleasant to use and harder upon machinery. The addition of copper sulphate (blue vitriol) to the formula has been recommended by some experiment stations, by others it is considered without insecticidal value,* and by some it is regarded as a positive injury to the insecticide properties of the spray.*

Variety of practice in the preparation of the spray is to be found. All methods provide for chemical union between lime and sulfur brought about by heating with water. The heat may be supplied in a variety of ways externally and the spray has been made by heating with caustic soda, potassium sulfide or an increased amount of quick lime.

The so-called self-boiled lime-sulfur-soda wash used in the experi-

* Bulletin No. 166, Calif. Agr. Exp. Sta., 1905.
* Bulletin No. 101, Bur. of Chem. U. S. Dept. of Agr., Feb., 1907.
* Ill. Agr. Exp. Sta. Bulletin No. 107, 1906.
* Wash. Agr. Exp. Sta. Bulletin No. 76, 1906.

ment referred to is a common formula where both quick lime and caustic soda produce the heat of the mixture.* Another formula sometimes used by growers provides for an excess of quick lime to produce the boiling heat. Others use this method except that hot water is required to quicken the slaking process. The formula using caustic soda, probably the best of the above self-boiled mixtures, though saving cost of boiling by fire, increases the cost of the mixture. At average local prices at the point where the experiment was conducted, the cost of the mixture was $3.45 per 200 gallons as compared with $2 per 200 gallons for the standard orchard-boiled wash.

It has seemed to the writer that attempts at preparing the mixtures without the aid of external heat has usually resulted in leaving a portion of the sulfur uncombined. This is indicated by the yellow color of the mixtures so prepared. A wide difference in the color of the sediment was noted in the mixtures prepared by different methods in the experiment. The ratio of sediment to liquid also showed wide differences. The strength of the lime-sulfur wash will depend upon the strength of the soluble portions and upon the sediment. The sediment is supposed to gradually decompose into nascent sulfur, which remains upon the tree and continues destructive to insect life for a considerable time. An excess of coarse sediment in the spray is a disadvantage in that it clogs the nozzles and increases the wear on the pump.

Lime-sulfur washes were originally boiled by fire two hours or more. Later observations show that less time is sufficient. About forty-five minutes will generally form as effective a spray as can be secured, though the proper time required for boiling must be indicated by the changing of the undiluted mixture in the boiling vessel from a yellowish to a dark amber color. A properly boiled mixture, after diluting for spraying, will be of a reddish orange color and have a greenish sediment. The lime and sulfur should be boiled in about one-fifth the total amount of water and then diluted with either hot or cold water to make desired quantity of spray. Undiluted material should not be allowed to remain over night in the boiling vessel, for it will harden. Standard lime-sulfur mixture is intended for immediate use. So caustic is the spray that the hands of one using it should be protected by gloves. Apparatus should be rinsed with water each time after using.

DIRECTIONS FOR PREPARING STANDARD LIME-SULFUR WASH. The following formula and brief description for preparation of a small amount of the standard lime-sulfur wash is recommended for Howard scale.

Formula.

Quick or lump lime	15 pounds
Flour or flowers of sulfur	15 pounds
Water	50 gallons

To prepare fifty gallons of spray place seven to ten gallons of

*N. Y. Agr. Exp. Sta. Geneva, Bulletin No. 247.

water in the boiling vessel. While the water is being heated by a hot fire, mix in a separate vessel fifteen pounds sulfur with enough water to form a thin paste. Add this sulfur paste to the water and bring the mixture to a temperature just below the boiling point. Now add fifteen pounds good lump lime. A violent slaking will at once take place. Keep cold water at hand, adding if necessary to prevent boiling over the sides of the vessel or to keep the mixture from becoming too thick. After the lime has ceased slaking, keep steadily boiling for forty-five minutes, stirring almost constantly, when it will be ready for dilution with hot or cold water to make up fifty gallons of spray. It is then ready to be strained and applied.

TIME TO SPRAY. Late spring will be the best time to spray for this insect, though a fall application, after the leaves are off, will be effective. It should always be borne in mind that the lime-sulfur wash is a caustic spray designed only for dormant trees and not to be sprayed upon trees in foliage. Late spring is preferable to early spring sprayings. It should not be delayed too late lest there be danger of injuring the tender fruit buds. Pear buds, though swollen may, ordinarily be sprayed with safety even when the minute green leaves are showing beyond the tips of the bud scales. After the green leaf rudiments are in view a cluster of rudimentary pears, each borne by separate pedicel or stalk, will be found within each swollen bud. One may probably spray with the mixture up to the time these bloom stalks separate into distinct buds, just before unfurling their first petals.

Orchardists should begin their spring spraying for this pest in ample time so that it may be completed before it is too late. The time allotted will depend upon local conditions such as size and number of trees, and kind of apparatus.

APPLICATION. Success in spraying against this insect, as with others, depends more upon the thoroughness with which the spraying is done than upon any other detail. All portions of the tree, from the tip of the twigs to the base of the trunk must be completely coated. Trees must be sprayed from all directions. Strong winds at time of spraying will sometimes make this a difficult undertaking. The tips of twigs around the outside of the tree and in the top should not be neglected. Fortunately the spray is of such a color that parts of the bark left uncovered may be readily detected. If such spots can be found, the spraying there should be repeated.

APPARATUS. Kind of apparatus used in preparing the wash will depend largely upon the amount to be used.

Prepared in a small way, iron kettles are found suitable, such as are shown in plate I. fig. II. For small amounts a very convenient and inexpensive boiling vat is made with No. 18 sheet iron bottom with fourteen-inch planks for sides. The ends of the tank are formed by bending upward the two ends of the iron bottom, without forming sharp angles. The outside dimensions are 6 ft. by 2 ft. 6 in. Before nailing on the iron bottom to the edges of the plank, insert a strip of felt between wood and iron and coat with a heavy lead paint. Nail

on the sheet iron tightly and mount the tank upon brick sidewalls. A low brick chimney is constructed at the rear connecting with the fire box beneath the vat. Such a vat is large enough to prepare 200 gallons of spray or more at once. There are many of these vats used about Grand Junction.

Boiling lime-sulfur with steam is by far the best method. Portable steam cookers, such as are used for cooking stock food ,are suited admirably to the purpose. Some spray machinery manufacturers have boilers on the market well adapted for this work. With them the boiling may be done in wooden barrels. A steam pipe or coil from the boiler is directed into the mixture and the strong jet of steam automatically stirs the liquid while the boiling is progressing.

Where large quantities are to be prepared, a steam boiling plant, such as the one shown in plate I, fig. I, will be needed. This plant is built upon most improved and modern ideas and is found indispensable for preparing lime-sulfur wash upon the 240-acre orchard of Mr. John Ashenfelter at Montrose. A large steam engine beneath supplies the steam, which is conducted in pipes into the boiling barrels, ten of which are arranged in a row upon an elevated platform. At one end of the building and at a higher level are the water storage tanks filled by gravity and supplying the water for boiling and dilution. The small building at the rear is built for a storage warehouse. The plant has a boiling capacity of 400 gallons of spray and the boiling barrels are emptied by gravity directly into the spray tank. The photo shows one spray tank in process of being filled.

The material may be applied by good strong hand pumps or larger spray outfits. A large number of gasoline power sprayers are in use for applying the mixture in the Grand Valley. Long spray poles and long lengths of hose are desirable. Nozzles of larger apertures than those used where a fine mist is desired are preferable.

A well appointed equipment will greatly lessen the cost and inconvenience of lime-sulfur spraying against the Howard scale. This is important since lime-sulfur spraying has become an essential part in the routine of orchard work.

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SUMMARY.

(1) The Howard scale is present in injurious numbers in many fruit orchards of Colorado.

(2) The pest was first discovered in this state and is supposed to have originated upon plants native to the locality.

(3) It is less destructive than the San Jose scale which, so far as is known, is not present in the state.

(4) The insect has been found to infest many varieties of fruits, but is primarily a pest of pear, plum and prune.

(5) Damage may result from the insects attaching themselves to either tree or fruit, where they absorb the sap as parasite. Trees may be killed outright or fruit may be rendered unmarketable from its "scaly" appearance.

(6) The insects when attached to the surface of fruit or tree are of minute size—about the size of a pin head.

(7) By rapid rate of increase they may produce enough individuals to completely encrust the surface of the plant attacked. It is their rate of increase and gregarious habit of life which make them so destructive.

(8) The female insects are wingless throughout their entire lives and except for a short period following hatching are entirely motionless.

(9) The spread of the insect is dependent largely upon agencies outside the control of the insect.

(10) Samples of scale insects found upon fruit trees should be sent to the entomologist of the Agricultural Experiment Station for determination.

(11) Natural parasites and predaceous insects preying upon the pest do much to hold it in check but have not, in the past, increased enough to make other measures unnecessary.

(12) The lime-sulfur wash applied in late spring before the buds open has been found a complete and practical remedy.

KEY TO ILLUSTRATIONS.

Plate I.—I, Plant for steam cooking several barrels of lime-sulfur mixture at once, owned by Mr. John Ashenfelter, Montrose, Colo.; II, cooking lime-sulfur in kettles; III, *Aspidiotus howardi*, (A) scales upon pear twig, (B) dead females' scales of last year, (C) young living female scales, (D) adult male scales, a male emerging at d—all enlarged seven times—drawn by Miriam A. Palmer; IV, photo of dead and living scale upon prune twig, considerably enlarged; V, pear showing large scales in depressions, also young white scales scattered about, somewhat enlarged; VI, pear with scales removed showing pits caused by the lice.

Plate II.—Howard scale, *Aspidiotus howardi* Ckll. I, Pygidium of female showing dorsal characters on the left (A), and ventral characters on the right (B), a, wax ducts; b, oval dorsal glands; c, grouped ventral glands, × 190; II, the same, showing variation in the number and form of the glandular hairs or plates; III, newly hatched young, × 95; IV, adult male, × 62. Original drawings by Miss Miriam A. Palmer.

Fig I.—Howard scale parasite, *Prospalta aurantii* greatly enlarged. After L. O. Howard, Bureau of Entomology, Washington, D. C.

Fig. 2.—Twice stabbed lady-beetle. *Chilocorus bivulverus*; larva, pupa and adult enlarged and the adult natural size.

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ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES 1906

BY

P. K. BLINN

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ALFALFA, SUGAR BEETS, CANTALOUPES

NOTES, 1906

By P. K. BLINN

ALFALFA

Improvement by Seed Selection—The alfalfa seed nursery established in 1905 for the selection and improvement of alfalfa, was given as uniform conditions as possible as to care and irrigation; yet there appeared a marked contrast in the size and the early development of six rows of Turkestan alfalfa in the center of the plat, as compared with four rows of native alfalfa on each side. The Turkestan alfalfa was up three inches high by April 1st, while the native rows had not begun to show above the ground; many of the Turkestan stools would measure six to eight inches in diameter, while the native stools would hardly measure three to four, as they broke through the surface of the ground. The Turkestan was also characterized by wide clover-like leaves, as compared with the native, though this character varied in individual plants.

Each stool in the plat consisted of one plant, the nursery having been thinned to one individual to a place; the rows were 20 inches apart and the plants about the same distance in the rows. Plate 2 shows the contrast in the plat, April 15, 1906.

Owing to the marked superiority revealed in the Turkestan alfalfa, it seemed advisable to begin the work of seed selection with this variety, and as we had secured a selection of seed from the most promising plants in the native rows the previous season, we accordingly cut out the rows of native alfalfa, and also eliminated all undesirable plants in the Turkestan rows.

Plate 3 is a view of 12 rows of new seeding from the seed above mentioned which was added to the nursery this year. During the season a close study was made of the individual plants to determine their variations desirable for seed selection. In the plat of over four hundred plants, sixteen were selected for their special characteristics.

Seed producing tendency was a prime consideration for obvious reasons, for how to get a good yield of alfalfa seed is an important question in Colorado. The variation in this respect of the individual plants in the plat was very marked and exceedingly promising of valuable results; for the results of tests so far, seem to indicate that these variations can be fixed through seed selection.

The following notes indicate the characteristics of the plants from which the seed was selected; in each case the seed was the

*This Bulletin is the report of progress of Mr. Blinn as Field Agent, for 1906. It was not prepared as a bulletin.

product of a single plant and had been cleaned. labeled and saved separately, and the original plant from which it came has been marked.

PART OF REPORT FROM ARKANSAS VALLEY FIELD AGENT

Plant 1.—Yield of seed, 66 grams; fine stems, thick set with leaves; desirable plant for hay; seed irregular in ripening; bloom, green pods and ripe seed on the plant at the same time.

Plant 2.—Yield of seed, 45 grams; many fine stems; very little rust or disease on the leaves; seed fairly uniform in ripening; a desirable type for hay.

Plant 3.—Yield, 53 grams; many short, thick stems; seed plump and uniform in ripening; style of stems desirable for supporting seed, but not promising for hay.

Plant 4.—Yield, 24 grams; few long, coarse stems; rust common on leaves; undesirable type.

Plant 5.—Yield, 24 grams; few long stems; seed fairly uniform in ripening, but not desirable for hay.

Plant 6.—Yield, 37 grams; stems long and coarse; seed irregular in ripening; undesirable type.

Plant 7.—Yield, 33 grams; long, coarse stems; seed irregular in ripening; undesirable type.

Plant 8.—Yield, 34 grams; seed head short and small; ripening uniform; not desirable for hay.

Plant 9.—Yield, 40 grams; stems fine; seed very uniform in ripening; a desirable type.

Plant 10.—Yield, 25 grams; a small plant; seed ripened uniformly, with no second growth of stems.

Plant 11.—Yield, 30 grams; stems and leaves free from rust or disease; seed uniform in ripening; a desirable type.

Plant 12.—Yield, 54 grams; fine, large plant; large clusters of bloom; large, uniform seed pods; ripening uniformly; a very desirable plant.

Plant 13.—Yield, 43 grams; fine stems; no rust; uniformly ripe; a desirable type.

Plant 14.—Yield, 41 grams; fine stems; small heads of seed; not regular in ripening.

Plant 15.—Yield, 44 grams; fine stems; no rust on leaves; a desirable type.

Plant 16.—Yield, 55 grams; many fine stems; leaves well retained; seed ripening fairly uniform, while the stems still remained green; very desirable type.

Plant 17.—Yield, 49 grams; seed from a native stool that grew on dry land with no irrigation; had remarkably large flowers that set uniform, with seed that ripened uniformly and was almost perfect in color and plumpness; stems desirable for hay; seed pods on adjacent plants under the same conditions blasted and failed to make seed.

The seed of some of the above plants was selected not for their desirable traits, but to test their future behavior and their reproducing power, and to determine the most potent tendency of the several types.

The average of those that were good seed yielders would amount to over one and a half ounces of clean seed to the plant; this computed for a theoretical yield to the acre, allowing four square feet to the plant, would give one thousand pounds per acre—a yield that does not seem impossible, and one that would be profitable even on highly valued land.

The following, Plate 4, is a view of two adjacent plants as they stood in the nursery row; the one to the left is plant No. 12.

The color contrast of the seed pods was not enough to show

1. A Characteristic Plant of Turkestan Alfalfa.
2. Turkestan Alfalfa Rows Bordered by Common Alfalfa, taken April 15th.
3. Alfalfa Nursery.
4. Two Alfalfa Plants.

UNIVERSITY OF NEBRASKA

PLATE V.
A Vine Rusted on Check Row.

PLATE VI.
Adjacent Vine Showing Resistance to Rust.

PLATE VII.
Cantaloupe Showing Perfect Netting and Internal Qualities.

the wonderful set of seed as it really was as compared with the plant to the right in the photograph. Both plants had developed under equal conditions in every way, and seemed equally vigorous; both bloomed freely, but while one set seed seemingly at every flower, the other would bloom and blast, which was also the case of the majority of the seeds in the plat; while a few such plants as Nos. 1, 3, 17 and 16 had nearly as much or more seed as No. 12.

Seed Production—In order to determine the conditions most favorable for the production of alfalfa seed, we have instituted a line of personal interviews with some of the most successful alfalfa seed growers, to ascertain their theories and methods regarding the problem; and from such data, together with results of co-operative tests and from our plat work, we hope to determine some of the factors that influence a yield of alfalfa seed, and thus enable the farmer to secure more profitable returns.

The importance of alfalfa in its relation to crop rotation for maintaining fertility is each year more apparent, as the yield from land continually taxed with beets or other crops is contrasted with the same crops grown on alfalfa sod. The breaking up of the old alfalfa fields and the seeding down of the worn out land each year, is creating a demand for alfalfa seed that bids fair to exceed the present rate of supply; for some reasons the present yield of alfalfa seed, even in the best producing sections, is not as good as in former years; and consequently there has been a steady advance in the price of alfalfa seed; this fact and the somewhat uncertainty of success in re-establishing a stand of alfalfa seems to deter many farmers from adopting a crop rotation that good judgment would seem to suggest that they should.

It is in view of increasing the yield of alfalfa seed and solving some of the difficulties of alfalfa growing, that we have undertaken this line of investigation.

BEETS

Under this topic we have continued efforts to develop a disease resisting beet. We have now about 50 pounds of seed produced from the second generation of mother beets since the selection of seed beets from the "curly top" affected fields of 1903. Since that year the trouble has not appeared in Colorado, and in order to test the merits of our selection at this time, we have sent to Dr. C. O. Townsend of the Department of Agriculture, about 25 pounds of this seed; he agreeing to send it out to portions of California and Utah, where the trouble occurs to some extent each year, and will report to us if the seed possesses any inherent resisiting qualities.

In this connection we have gained considerable information relative to the problem of beet seed growing, the methods and conditions necessary for securing a yield of beet seed. Some of the points that have grown out of our experience in this line might be summarized as follows:

1. In a general selection of mother beets for growing seed, there is a wide variation in the seed producing tendency of individuals, and by selecting along this line, our tests have demonstrated that the seed yield can be materially increased.

2. So far, in the beet-growing tests there has usually been a large number of beets that would not grow a seed stalk, but only make a vegetating growth of leaves and root; this feature has varied somewhat with seasons, but our tests have indicated that the soil conditions and the manner of setting out the beets are very essential to uniform seed production.

3. Our method of siloing mother beets has been to silo late in the season, selecting only well matured beets of good shape and size, removing the leaves without injury to the center or crown buds, then layer the beets in dry soil in deep, narrow pits, to protect from frost. Ventilation is necessary, also protection from snows and rain finding their way into the silo.

4. Mother beets should be set out early in April, in this section, selecting a fertile soil, well drained, so that moisture conditions may be controlled.

5. To insure uniform conditions in setting out the beets, a deep furrow should be thrown out and still loosening the soil in the bottom of the furrow, the beets may then be set in the furrows with the crown about level with the surface of the ground; the soil may then be thrown to the beets with a small plow or cultivator, then a small stream of water is run on each side of the row which settles the soil around each beet uniformly. After the beets have started, any soil that may cover the crown is carefully removed; frequent cultivation and irrigation are then applied to induce a rapid growth until the seed stalk appears, then less water is necessary, until the seed begins to ripen, when the water should be withheld.

6. After the seed stalks are well developed, hilling up the rows with soil will prevent much breakage by wind or heavy loads of seed; tying the stalks together with twine is also sometimes necessary.

7. The injury from the false chinch bug is less frequent on alfalfa and grain land that has been kept clean from weeds upon which insects thrive. Thus far, mother beets on clean land surrounded by grain of some kind, have not been attacked by the insect. A flock of young chickens or turkeys has proven a protection from grasshoppers when they are cooped on or near the plat of mother beets.

CANTALOUPES

The question of maintaining or improving the quality of the Rocky Ford cantaloupes becomes more pertinent each year, as we hear the unsatisfactory reports of the irregular quality of the product in all the various markets. The many inquiries and requests for seed from the farmers and the experiment stations throughout the melon growing sections of the United States is

evidence of the urgent needs, and the manifest interest in our work of developing a disease resisting cantaloupe. In order to test the merits of our rust resisting selection under various conditions, we have furnished a few seed to all inquirers from various parts of the United States to those who were willing to make the test in a co-operative way.

As our work of selection was only well begun, we could only furnish what might be termed a second grade selection of seed, as the few seed of the first selection was reserved for our own work. The following are brief extracts from the reports that have been received so far at this time:

"The rust-resistant plat furnished fine melons after the other plats were all dead with rust."—E. C. Green, Texas Experiment Station.

"The melon seed received from you this spring, gave the best melons I have had in previous seasons."—J. D. Fraser, Leamington, Ontario.

"I found the Pollock, or rust-resistant melon superior in quality to the others, but many of them grew rather large."—Chas. L. Goodrich, Glendale, Maryland.

"The reports of three growers who tried the seed you sent me, show that this melon was unusually free from rust, although other melons in the immediate vicinity were badly injured by it."—Samuel B. Green, Minnesota Experiment Station, St. Anthony's Park.

"Until about a week ago the vines showed little or no rust, but at the present writing the leaves are badly spotted; the fruit is good size, and the vines may withstand the attacks until after the melons ripen; I think I gave the variety a very severe test, as the seed were planted on soil that a year ago was devoted to the same crop, which was entirely wiped out by the rust."—H. D. Haskins, Hatch Experiment Station, Amherst, Mass.

"The vines from the disease-resistant seed which you sent me, certainly did resist diseases much better than the old Netted Gem."—F. L. Stevens, North Carolina Experiment Station, Raleigh, N. C.

"I ran all other melons out of the hotels with the rust-resistant "Pollock" seed I got from you."—A. Van Wagenen, Sioux City, Iowa.

From twenty-nine reports from growers in New Jersey, who tested the rust-resisting seed that we furnished Byron D. Halsted of the New Jersey Experiment Station, eighteen reported very favorable results; eight reported that they observed no difference, and three made unfavorable reports; the seed furnished for this test was pure "Pollock" strain, which only had had one year's selection for the rust-resistant feature.

The popularity of the cantaloupe as a fruit on the American table does not seem to diminish, nor does the output or the returns to the grower seem to decrease; these facts are unquestionably due to the greater attention being paid to the quality of the seed selected for planting and also the improved refrigerating and marketing facilities. About the only progress the melon growers have made in regard to seed selection, is the almost unanimous selection and use of single strains of seed by the various associations, thus insuring uniformity. In general, they have selected the strains that were early, prolific, uniform, and also desirable in appearance, with little or no attention being paid to disease-resisting tendencies; in fact, some prejudice exists against the rust-resisting strain, as it is thought to be later and less productive than the strains in general use. This apparent lateness of the rust-resistant strain is probably due to abnormal ripening of the other strains, rather than to any inherent lateness in the rust-resistant strain.

The past season proved very favorable for the development of the rust trouble, and the melon fields went down nearly three weeks earlier than usual; our rust-resistant selection remained green until the majority of the fields were dead, and some of the most markedly resistant plants in the plat remained green until frost, this in spite of the fact that the seed was grown on soil that for four consecutive years had been badly infested with rust, the idea being to develop the quality under as adverse conditions as possible, consequently, irrigation was applied in excess to favor the development of the rust. The plat was planted with the seed of nine individual melons, which had passed the rigid test of selection on the same plat the previous season; one row was planted as a "check" row; seed from a very perfect melon, but from a field that had not been selected for rust resistance. The plat developed nicely until about August 15. The season was characterized by frequent showers and heavy dews, and in July the rust spots appeared on all the early melon fields, and when the first picking began, about August 10th, the fields were getting brown with rust, as was also the check row in our plat, while the other rows were comparatively free from rust. The following photographic record represents the relative condition of the vines on the check row and adjacent rust-resisting row on August 20th; the whole plat having received the same treatment in every respect.

When the rust had developed to some extent on the plat (which began at least ten days later than any other plat under equal conditions), the plat was carefully studied, and over one hundred resistant plants were staked and numbered, and each day as the ripe melons were gathered, these were marked with the number of the hill and the seed saved separately and the description made of the qualities of each. At the close of the season, the plat was gone over and notes taken of the rusted condition of the various plants; this revealed the fact that a few of the whole number, had remained resistant later than others. With the system of numbering used, this seed can be identified and used in further developing this important quality.

Careful consideration and a great deal of time has been devoted to selecting melons with a view to improving their keeping qualities, as well as flavor and other qualities desired in a perfect melon. The following photograph reveals some desirable internal and external qualities shown in some of the melons of our selection.

In order to develop early maturity in our rust-resistant strain, we have made arrangements for a co-operative test, by having some of this seed grown in Canada, the product of which will be tested this coming year at Rocky Ford, to indicate the influence of latitude on early maturity.

Some investigational work in regard to the life history of the melon louse, and the means of combatting it was taken up in co-operation with and under the direction of Prof. C. P. Gillette.

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FRUIT GROWERS' ASSOCIATIONS

BY

W. PADDOCK

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FRUIT GROWERS' ASSOCIATIONS

W. PADDOCK

The Western Slope District—The geographical location of Colorado, particularly of the fruit district on the Western Slope, is such that it is necessary for the majority of fruit growers to sell their products through associations. This is especially true since the product of her orchards has become so great that the bulk of the fruit must be sold outside of the State. Here we must compete for the markets, usually at a disadvantage because of high, and many times unjust, transportation rates. Car load lots then must be the unit of shipment, but what is more important, the shipper must know the condition of the markets each day in order to place his produce to the best advantage. It must be apparent that the marketing of fruit requires a high type of business ability, and the average grower has small chance in the markets under these conditions. This was particularly true a few years ago before the associations had become important factors in marketing. Since their advent prices have been much more stable, and the entire section has been benefited thereby. Formerly the grower had no means of becoming acquainted with the condition of the outside market, so he was more or less at the mercy of the buyer.

There is a wide difference between the prices received by the producers of farm products and those which the consumers are compelled to pay. Could the two classes deal directly with each other, the law of supply and demand would control prices and each class would be greatly benefited. However, we can scarcely hope to reach this consummation, but much may be done to better present conditions if the farmers can only grasp their opportunities.

Fruit growers' associations are not new institutions in Colorado. Perhaps in no state east of the Pacific coast have they been more successful or longer in operation. But there are still many localities in the State which are either not organized, or where the existing associations have not been so successful as is desirable. Then there are localities where special crops, other than fruit, are grown where the growers would be greatly benefited by marketing their produce through associations. An attempt is made in the following pages to describe the workings of the fruit associations with the idea of being helpful to those who may be interested in such organizations.

The growing of fruit itself is an intricate business and is usually all that one man should attempt. If he makes a success of orcharding, the time of the average man will be fully occupied.

Then he can afford neither the time nor money to keep posted on the conditions of the markets every day, or to become acquainted with the many intricacies incident to marketing.

An association, on the other hand, can afford many of these things, because of the volume of business involved. For instance, the manager must have daily telegraphic reports on the condition of the markets; he often has a personal acquaintance with the buyers, and he finds it to his advantage to make occasional trips for the purpose, even to distant states. He can also have a system of diverting cars after they have been sent out of the State and thus avoid a glutted market, or send his fruit where it will sell to better advantage than where it was first planned. The icing of the cars can also be properly looked after. Associations are often the means of getting lower freight rates, because the hauling of several hundred cars is an item worth competing for, and in a number of instances, the managers have been successful in getting rates changed to their advantage. Such rates are, of course, open to all shippers. Buyers often want a number of car loads of a certain variety and are willing to pay a premium if their wants can be supplied, and not infrequently such sales are the means of disposing of large amounts of the inferior varieties or grades. An individual is seldom in a position to take advantage of such opportunities. Associations are successful in maintaining a uniform pack, and by this means they establish a reputation for their goods. Usually the best grades of fruit are sold as a certain brand. The brand, which should be copyrighted, is sufficient guarantee for the quality, or, at least, it must be if the association expects to gain and hold a reputation.

Supplies of various kinds, which are used on fruit farms, may be bought at wholesale, often in car load lots, as indicated on Page 13, which is quite an advantage, especially in such items as spray and box materials. The saving which the association makes to the growers in this way is no small item, as everything is bought at wholesale. The prices to growers are only slightly in excess of actual cost. And then it is advantageous to keep a certain amount of the better class of help from year to year and to furnish them with employment, so a more or less extensive jobbing business may be carried on, as indicated on Page 13. It will be noticed that not only is a large amount of fruit growers' supplies handled, but a wholesale business in other lines may be done, depending upon the demands of the locality.

And, finally, an association can be handled more economically than it is possible for most individuals to market their fruit, unless they depend entirely upon the traveling buyer, or resort to the doubtful expedient of consigning to commission men.

Given a capable manager and a wise board of directors, there

can be but small chance of failure under our conditions. But men who are capable of handling 500 to 1,500 cars of fruit at a good profit are not common, and when one is found, every effort should be made to retain him. One of the first things that should be done for the manager, when a capable one is found, is to give him a salary in proportion to the amount of business done and the responsibility which must be carried. The latter item is certainly important when we consider that he may be responsible for a number of car loads of a very perishable product, which are on the road at once. Then, too much supervision on the part of the board of directors, who usually have small knowledge of the business, only hampers the manager and restricts his personality. If he cannot make a success of the association in his own way, the advice or help of the directors will be of little use. A much better plan is to give the manager a fair chance to work out his own ideas, and then if he fails, try another. But right here is the cause of most of the failures; too much supervision by the directors and unjust criticism and fault finding on the part of the stockholders.

A common source of discontent is the rumor that a neighbor in another association has received a higher price for his produce, or that an outside buyer is offering attractive prices. Unscrupulous firms frequently adopt the latter method of getting consignments only to swindle the grower. If there was not some decided advantage in buying direct from the growers, these firms would not go to the expense of maintaining an agent in the field when just as good or better fruit could be had from the association.

The association idea is no longer an experiment, and when each one does his share to maintain the reputation of the fruit, and the volume of business is sufficient to pay expenses, there is small chance of failure. The history of associations, the country over, shows that petty jealousies and distrust on the part of the members is the common cause of failure. One writer has summed up the subject in the following terse sentences:

"All classes of farmers are constitutionally and proverbially distrustful of other people and of one another. In a fruit association there arise (such is the experience) the most inveterate jealousies. Each man thinks he is furnishing a better grade of fruit than his neighbor, though all share alike in the profits. Each one fears the other will reap some special advantage somehow. In particular, the appointment of managers, superintendents, supervisors of grading, shipping agents, and all other officials of the company, offers a sufficient opportunity for the elaboration of all sorts of neighborhood quarrels. Each man thinks he ought to be manager, and when one man is finally chosen he is usually suspected of all sorts of favoritism. In any case he is apt to be hampered in his business relations by committees, boards of directors, and various kinds of red tape and foolishness. Often he has to consult a committee before taking any important action. * * *

"Another difficulty which arises from the same cause is that subscribers to such an association never want to pay a manager's wages. Two or three dollars a day is considered good pay. Yet such a man is com-

pelled at times to handle thousands of dollars' worth of business. The position is such as, in ordinary business life, would command a salary of five thousand dollars a year or more."—(Waugh; Fruit Harvesting, Storing, Marketing.)

Growers who are not members may ship through the association on the same terms, but they are usually required to pay more for supplies.

All of the larger concerns require both members and non-members, for whom they ship, to bring all their fruit to the association.

Formerly stockholders were allowed to sell their own fruit by paying the association a small premium. Neither were objections made to members filling orders from near-by towns. But, as these means of disposing of fruit are manifestly unfair to a majority of the association members, they have come to be looked upon with disfavor and in most instances are no longer allowed.

One of the strong points in favor of the association idea, as worked out in Colorado, is the possibility of a fairly uniform pack. This results in better prices, since buyers have the assurance that all associations strive to make their goods as nearly uniform as possible. Then, contrary to the idea often advanced that poor fruit brings as great a price as good, the most rigid grading must be practiced, and the intention is to place each fruit in its proper grade, thus only the best grade sells for the highest price, and, indeed, the grower of inferior fruit is fortunate to dispose of his crop at all.

There are two methods of packing and grading fruit; in one instance, the association does all the packing, the growers delivering the fruit to the packing house just as it is taken from the trees. Here the packers, under the direction of a superintendent, sort the fruit into the various grades, and at the same time pack it into boxes or crates. Should there be any culls, they are returned to the grower and are at his disposal.

Each grower is given a number, which is used to designate his fruit throughout the season. As each box is packed, it is marked with his number and the grade. When the boxes are loaded into the cars, the number of boxes, the varieties and the various grades which belong to any grower are kept account of and duly recorded. In this way the price for each box of fruit in any car is easily determined.

But where there is a very large amount of fruit to be handled it is impossible for the association to do the packing, consequently the growers assume this work. With this arrangement, the association employs an inspector, whose duty it is to inspect each load as it is delivered. This he does by opening the boxes on the side, in the case of apples, when a good estimate of the contents may be made. If the pack is satisfactory, not more than two boxes may be opened. If unsatisfactory, several may be examined, and if all

run under the inspector's standard, the entire load must either be placed in a lower grade or else be repacked.

It will be seen that a great deal depends on the inspector, and that it is a difficult position to fill. Upon him depends the reputation of the association, so he must be entirely free to do the work as he sees fit.

Each man's fruit is kept track of by numbers, as in the former case.

Most of the associations have now adopted the latter system, although nearly all have tried the former. The ideal method is, no doubt, to have all packing done at a central building, but a limit to the amount of fruit which can be handled is soon reached. It is found difficult in practice to keep track of a large number of packers at a central point, and careless work is the result. But when each grower looks after his own packing, he has a wholesome respect for the decision of the inspector. It is very expensive to repack a lot of fruit, and if he is obliged to do this, or else let it be sold as a lower grade, even on a single load, it usually results in greater pains being taken in the future. But with the best of systems, poorly packed fruit will occasionally find its way to market.

The association charges a commission on all sales, usually five per cent., to defray expenses. Then, in case the packing is done by the association, an additional charge is made to cover the cost of the box and packing. Any surplus is, of course, distributed as premiums. Any fruit grower may become a member of the association so long as there is stock for sale, and the owner of one share is entitled to all of its privileges. The number of shares one individual may own is limited.

The growers are generally asked and, in many instances, required to furnish an estimate of their crop. In the smaller associations, the manager sometimes secures this information by visiting the orchards in person. This estimate is made early in the fall, or not until damage by worms and other causes is practically over and the crop is secure. With this knowledge in hand, the manager can enter into contracts for delivering certain amounts of various varieties or grades.

The system of selling has been radically changed within the past few years. Formerly practically all of the fruit was consigned to commission men, who, as a class, it may be truthfully said, are inclined to do the best they can by their constituents. But too often the experience has been otherwise. Not infrequently has it happened that shipments consigned to a distant city have been reported as not being up to grade, or not in good condition, so the market price could not be realized. In such cases, though the manager may be certain that his fruit is as he represented, he is often unable

to help himself, so must take what he can get. But of late years, the plan of selling F. O. B. is being practiced more and more, and this is largely due to the organized efforts of the associations. Consignments are only made to well known firms, and much of this fruit is sold at auction.

But even with this arrangement difficulties arise, so in order to protect themselves, the larger associations have an agent at the more important distributing points. It is the duty of the agent, or broker, to inspect all cars which come into his territory, as near the destination as possible, and thus protect the association from dishonest buyers. He also is on hand to adjust the differences which arise when the fruit actually reaches the buyer in poor condition.

Express shipments are only made to comparatively near-by points, and with such shipments, the growers receive exactly what the fruit brings less the expressage and the association's commission. It is usually the early fruits that are expressed, but prohibitive rates prevent any very large amount of business being done in this way.

An association, well managed, is always a benefit to the entire community, in that it builds up a reputation for the fruit, and holds up prices, inasmuch as there is not that tendency, even among non-members, to bid one against another in marketing. This is well illustrated in the case of a prominent fruit grower who is a member of one of our successful associations. Because of superior ability as an orchardist and having a large orchard of choice varieties, he could easily get a price somewhat in excess of that which he receives through the association. But he realizes that it is the association which has built up and sustains the reputation of the locality, and should it fail, the chances are that local competition would again lower prices.

In addition to this, it may be said that the managers are constantly insisting on the necessity of growing better fruit, and so have been instrumental in introducing new and improved methods of culture and, in many instances, have been advance agents for the Experiment Station, and in this capacity have made our work pleasant, as well as acceptable, to the fruit growers.

The Northern District—By the Northern District is understood the territory which is adjacent to Denver and the country north along the foothills to Fort Collins. Associations are operating in most of these towns, but as small fruits are the principal crops handled, express shipments are the rule. The managers find that, usually, it does not pay to make F. O. B. sales of small fruits to the retail dealers, for the reason that such stores change hands frequently, consequently many bad debts result. This is the prin-

cipal difference in the management of the associations in the different sections.

The Boulder County Fruit Growers' Association at Boulder, has been the most successful. Its success is undoubtedly due to an efficient manager and a board of directors who have been content to let the manager handle the business.

With a much smaller volume of business and a much more perishable product, association management is more difficult than in many other localities. Yet the Boulder Association has not failed to make a good dividend on the stock every year since its organization. This is also one of the few which have branched out into other lines and have thus been enabled to do business throughout the year.

The examples cited are of successful institutions which have been in operation a sufficient length of time to thoroughly demonstrate the practibility of the system.

It must not be inferred, however, that other sections of the State have neglected to take advantage of the opportunities which combination in marketing affords.

Several associations in the Arkansas Valley have become prominent, but their management does not differ from that which has already been described.

The following list of fruit and produce and cantaloupe associations, which are now doing business in the State, will show what an important factor this method of selling horticultural produce has become:

LIST OF FRUIT AND PRODUCE AND CANTALOUPE ASSOCIATIONS NOW DOING BUSINESS IN THE STATE.

Amity Cantaloupe Growers' Association, Amity, Colo.
Bent County Melon Growers' Association, Las Animas, Colo.
Boulder County Fruit Growers' Association, Boulder, Colo.
Capitol Hill Melon Growers' Association, Rocky Ford, Colo.
Delta County Fruit Growers' Association, Delta, Colo.
Denver Fruit and Vegetable Association, Denver, Colo.
Fair Mount Melon Growers' Association, Swink, Colo.
Fremont County Fruit Growers' Association, Canon City, Colo.
Fruita Fruit and Produce Association Fruita, Colo.
Fort Collins Fruit Growers' Association, Fort Collins, Colo.
Fowler Melon Growers' Association, Fowler, Colo.
Granada Melon Growers' Association, Granada, Colo.
Grand Junction Fruit Growers' Association, Grand Junction, Colo.
Branches at Clifton, Palisade and Whitewater.
Grand Valley Fruit & Produce Association, Grand Junction, Colo.
Independent Fruit Growers' Association, Grand Junction, Colo.
Kouns Party Cantaloupe Growers' Association, Rocky Ford, Colo.
Lamar Melon Growers' Association, Lamar, Colo.
La Junta Melon and Produce Co., La Junta, Colo.
Longmont Produce Exchange, Longmont, Colo.
Loveland Fruit Growers' Association, Loveland, Colo.
Manzanola Fruit Association, Manzanola, Colo.

Manzanola Orchard Association, Manzanola, Colo.
Newdale Melon Growers' Association, Swink, Colo.
North Fork Fruit Growers' Association, Paonia, Colo.
Palisade Fruit Growers' Association, Palisade, Colo.
Peach Growers' Association, Palisade, Colo.
Plateau and Debeque Fruit, Honey and Produce Ass'n, Debeque, Colo.
Rifle Fruit and Produce Association, Rifle, Colo.
Roaring Fork Potato Growers' Association, Carbondale, Colo.
Rocky Ford Melon Growers' Association, Rocky Ford, Colo.
San Juan Fruit and Produce Growers' Association, Durango, Colorado, and Farmington, New Mexico.
Surface Creek Fruit Growers' Association, Austin, Colo.
Woods Melon Growers' Association, Las Animas, Colo.

A STATE ORGANIZATION.

Now that local associations have become established institutions, there yet remains to be organized a combination of associations. A state association would perhaps not meet our wants so well as district organizations, since the fruit growing localities are widely separated and their conditions so diverse. It is true that the managers now work together to some extent, particularly on the Western Slope, but they all recognize that a much closer union would be desirable.

Not only would our fruit become better known and better prices result, but economy along many lines would be effected. If one man could have supervision of the sales of all associations, in a given section, the last trace of local competition would be done away with. The railroads, as well as the large dealers, could be dealt with to much better advantage by one man representing a group of associations than by a number of men representing the divided interest of several. Then, in the buying of supplies, one man could not only do the work more economically, but he would be able to get much better rates for the same reasons. The same line of argument would hold good for all phases of association management.

The time is not yet ripe, perhaps, for such an organization, but it is fast approaching. It is safe to say that the complete control of the market situation, to which the fruit growers of Colorado are entitled, will only be realized when such a combination is effected.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

The following report of the Grand Junction Association will assist in giving an insight into this form of successful co-operation. This Association has been chosen for the purpose of illustration, not because it is the most successful, but for the reason that it is the oldest and is doing the largest business of any in the State. This Association was started in 1891, when a few growers combined and appointed one of their number salesman of their fruit for

the season. This arrangement continued with varying degrees of success up to 1897, when it became apparent that the increased business, if no other cause, would necessitate employing a manager, by the year, who should devote his entire time to the association. Accordingly this was done, and the business has increased year by year, as shown below. That the majority of the stockholders are satisfied with the workings of the Association is proven by their loyalty and by the fact that the capital stock has recently been increased to $100,000, for the purpose of accommodating the increasing number of members.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

GROWTH OF BUSINESS.

Year.	Paid Growers.	Total Business.	Cars Shipped.
1897	$ 54,085.00	$ 88,937.00	167
1898	21,785.00	43,750.00	89
1899	21,346.00	56,591.00	82
1900	68,323.00	114,590.00	202
1901	98,972.90	153,380.00	256
1902	195,975.15	287,887.15	613
1903	247,188.45	339,305.41	682
1904	437,154.33	557,291.11	1,282
1905	475,763.00	608,403.30	797
1906	555,813.44	814,278.62	1,036

Number of stockholders January, 1907..... 666
Number of shares of stock sold to January, 1907....14,169

STATEMENT FOR SEASON 1906.

Fruit Shipments in Detail.

	Packages.	Amount.	Avg.
Extra Peaches	136,162		
Fancy Peaches	139,917	$207,936.19	.45
Choice Peaches	151,438		
Unwrapped Peaches	33,397		
Carrier Peaches	295	177.04	.60
Total	461,209	$208,113.23	
Fancy Pears	87,157	$100,104.49	1.15
Six Tier and Choice	31,425	20,712.42	.66
Half Boxes Pears	6,007	2,878.73	.48
Total	124,589	$123,695.64	
Fancy Apples	128,369	$129,054.14	1.01
Choice Apples	82,955	46,555.14	.56
Half Boxes	2,725	1,235.02	.45
Total	214,049	$176,844.30	
Crates Plums	16,857	$ 8,765.69	.52
Boxes Plums	8,096	1,896.02	.23
Total	24,953	$ 10,661.71	
Crates Grapes	8,382	$ 7,060.79	.84
Baskets Grapes	2,102	457.91	.22
Total	10,484	$ 7,518.70	
Crates Apricots	8,312	$ 5,263.96	.63
Boxes Tomatoes	3,887	1,395.13	.36
Boxes Crab Apples	322	126.54	.39
Jumbo & Stand Cants	13,087	12,219.21	.93
Pony Crates Cants	2,231	1,083.32	.49
Total	15,318	$ 13,302.53	
Crates Strawberries	1,199	$ 2,794.48	2.33
Crates Cherries	1,276	1,910.17	1.50
Cases Honey	1,652	4,187.05	2.54

Shipments of fruit for the season aggregate 867,250 packages, or 28,805,828 pounds, equal to 1,152 cars of 25,000 pounds each; 1,017 cars by freight, and the balance, equal to 135 cars, by express and local freight.

	Cars.
Amount of fruit shipped in car lots	1,017
Potatoes shipped in car lots	19
Total	1,036

Business of 1906.

Merchandise sales	$248,779.25
Fruit sales	565,499.37
Total	$814,278.62
Total amount paid to growers	$555,813.44

Cars Received.

	Cars.
Box shooks	123
Wrapping paper	6
Berry boxes and baskets	3
Spraying outfits	3
Nails	3
Bee supplies	1
Spray materials	22
Salt	7
Oranges and lemons	22
Nuts	2
Paper and paper bags	3
Hay	20
Grain sacks	1
Sweet potatoes	1
Cabbage	3
California potatoes	1
Manitou water	2
Beans	1
Total	224
Cars sent out	1,036
Cars received	224
Total cars in and out	1,260

Where the Fruit Went.

	Cars.
California	33
Colorado	146
Illinois	70
Indiana	1
Indian Territory	18
Iowa	76
Kansas	24
Louisiana	60
Maryland	12
Massachusetts	15
Mexico	3
Minnesota	59
Missouri	31
Nebraska	72
New York	76
North Dakota	1
Ohio	2
Oklahoma	15
Pennsylvania	28
Quebec	2
South Dakota	46
Texas	208
Tennessee	2
Utah	1
Wisconsin	12
Wyoming	4

BY-LAWS OF THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION

I.

The name of the said Association shall be the Grand Junction Fruit Growers' Association.

II.

The objects for which the said Association is created are to buy and sell fruit, vegetables, hogs, meat stock and all the products of Mesa County, both fresh and manufactured; to erect, operate and maintain canning and packing factories and commission houses; to manufacture any and all products of Mesa County; to lease, mortgage and sell said business, and to borrow money for carrying on the same, and to pledge their property and franchise for such purpose. To acquire by purchase, or otherwise, and own real estate, buildings, machinery and all the necessary power and power plants for carrying on said premises, and to lease, mortgage and sell the same.

III.

The term of existence of said Association shall be twenty years.

IV.

The capital stock of the said Association shall be twenty-five thousand dollars, divided into five thousand shares of five dollars each.

V.

The number of Directors of said Association shall be seven, and the names of those who shall manage the affairs of the Association for the first year of its existence are C. W. Steele, A. A. Miller, J. W. Rose, R. W. Shropshire, J. H. Smith, P. A. Rice and A. B. Hoyt.

VI.

The principal office of said Association shall be kept at Grand Junction in the said County, and the principal business of said Association shall be carried on in said County of Mesa.

VII.

The stock of said Association shall be non-assessable.

VIII.

The Directors shall have power to make such prudential By-Laws as they may deem proper for the management of the affairs of the Association not inconsistent with the laws of this State, for the purpose of carrying on all kinds of business within the objects and purposes of the Association.

BY-LAWS.

ARTICLE I.

Section 1. The Board of Directors provided for in the articles of incorporation of this Association, shall be elected annually at the regular annual meeting of the stockholders, as hereinafter provided, and shall hold their office until their successors are elected and qualified.

Section 2. Said Directors shall be stockholders in said Association and shall be fruit growers in Grand Valley and shall be residents of Mesa County Colorado.

Section 3. Any vacancy occurring in the Board of Directors shall be filled by the remaining members of the Board.

ARTICLE II.

Section 1. The Board of Directors shall, as soon as may be, after their election, elect a President and Vice-President from among their number, who shall hold their offices for one year, and at said meeting the said Board shall appoint a Secretary, Treasurer, and Manager, who shall be subject to removal at any time.

Section 2. The Secretary, Treasurer, and Manager, shall each, when required by the Board, give bond in such sum and with such security as the Directors may require, conditioned on the faithful performance of their duties, and to turn over to their successors in office all books, papers, vouchers, money, funds and property of whatsoever kind or nature belonging to the Association, upon the expiration of their respective terms of office, or upon their being removed therefrom, or with such other conditions as may be proper.

Section 3. The President shall preside at all meetings of the Directors or Stockholders. He shall sign as President all certificates of stock, and all other contracts and other instruments in writing, which may have been ordered by the Board of Directors.

Section 4. The Vice-President shall, in the absence of or disability of the President, perform his duties.

Section 5. The Manager shall have full charge of the commercial and shipping department of the Association. He shall receive all money arising from the sale of fruit and other commodities handled by the Association, and pay the same to the parties entitled thereto, and render a true account thereof; and he shall also be the Treasurer of this Association and safely keep all money belonging to the Association, and disburse the same under the direction of the Board of Directors, except as herein above set forth.

Section 6. The Secretary shall keep a record of the proceedings of the Board of Directors and also of the meetings of the Stockholders. He shall also keep a book of blank certificates of stock, fill up and countersign all certificates issued, and make the corresponding entries upon the marginal stub of each certificate issued. He shall keep a stock ledger in due form, showing the number of shares issued to and transferred by any stockholder and date of issuance and transfer. He shall have charge of the corporate seal and affix the same to all instruments requiring a seal. He shall keep in the manner prescribed by the Board of Directors, all accounts of the Association with its stockholders, in books provided for such purpose. He shall discharge such other duties as pertain to his office, and as may be prescribed by the Board of Directors.

Section 7. These By-Laws may be amended by the Board of Directors at any special meeting thereof called for that purpose, a notice of such proposed amendment being given in the call for such special meeting.

ARTICLE III.

Section 1. The regular meetings of the Board of Directors shall be held at the office of the Company, on the first (1st) day of each month, except when the first day comes on Sunday or legal holiday, then on the following day.

Special meetings of the Board of Directors may be called by the President when he may deem it expedient or necessary, or by the Secretary, upon the request of any three membrs of said Board.

Section 2. A majority of the Board of Directors shall constitute a quorum for the transaction of business, but a less number may adjourn from day to day upon giving notice to absent members of the said Board, of such adjournment.

Section 3. The Board of directors shall have power:

First—To call special meetings of the stockholders whenever they deem it necessary, by publishing a notice of such meeting once a week for two weeks next preceding such meeting in some newspaper published in Grand Junction, Colorado.

Fancy Apples.

Winesap, Grimes Golden, Missouri Pippin, Red Romanite, Geniton, and kindred varieties, must be two and one-fourth (2¼) inches in diameter and up. Jonathan, Arkansas Black, Ben Davis, Gano, Willow Twig, Shackelford, Pearmain, Mammoth Black Twig, Rome Beauty, W .W. Pippin, Mann, Talman Sweet, Dominie, McIntosh, Wealthy, Steele's Red, Lawver, Baldwin, Huntsman, Spy, Minkler, Stark, Smith Cider, Walbridge, Pewaukee, York Imperial, etc., two and one-half (2½) inches in diameter and up. absolutely free from worms and other defects, bright and normal color, and shapely in form.

Choice.

Shall not be less than two and one-fourth (2¼) inches in diameter and reasonably free from worms, in other words, only stock a little below fancy. Throw away your trash, it won't pay freight. We also advise using the diamond pack.

The above rules for sizes do not apply to early summer varieties of apples; we will only ship one grade—Fancy.

Fancy Pears.

Must be free from worms, smooth and of good shape; gross weight, 53 pounds of more. The number of tiers must be stamped on the box.

Choice.

Reasonably free from worms; in other words, only a little below Fancy.

Plums—Prunes.

The large fancy Hungarian, Italian, Botan, Green Gage, Egg, etc., are put up in four basket crates, well filled, net weight 20 pounds, or more. Small varieties, Wild Goose, Mariana, Damson, and the smaller plums of all varieties, in two and one-half (2½) inch boxes, well-filled, net weight 16 pounds, or more.

Grapes.

Concords in 8-lb Climax baskets, and should be well-filled. Muscat, Rose Peru, Tokay, Purple Damascus, Black Hamburg, in four basket crates, same as California, and must weigh 28 pounds or more gross. See rule for packing grapes.

Cantaloupes.

Both standard and pony crates must contain 45 melons and be tight in the crate.

PUT YOUR NUMBER, VARIETY, AND GRADE ON THE UPPER LEFT HAND CORNER OF THE BLANK END OF THE BOX.

Any one who does not know when to pick fruit, or how to pack it, should consult with our Inspector, or their neighbors.

To Dealers.

In ordering peaches by wire or letter, the different grades will be known as Extra, Fancy and Choice. We guarantee our pack to grade as above, and in case they do not, please advise us, giving stencil number.

THE GRAND JUNCTION FRUIT GROWERS' ASSOCIATION.

Bulletin 123 January, 1908

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

THE PLAINS

SOME PRESS BULLETINS

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1908

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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*After March 1, 1908.

THE PLAINS

PRESS BULLETINS

This bulletin is made up of a number of press bulletins relating to the Plains, and giving advice to Plains settlers. They have been reprinted under this form for convenience. They consist of:

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ADVICE TO PLAINS SETTLERS.

BY J. E. PAYNE.*

We recognize it as a fact that many new settlers have taken up residence in the Plains region during the last few months who have merely enough capital to put up houses, break a few acres of sod, and live during the first six months.

The people cannot wait for results promised by the exploiters of "Scientific Soil Culture." They must have results this season. It is to this class of people that we would address the following suggestions:

First. If you have a milch cow give her the best care possible, and get as many more as you can. Sell cream, or make good butter or cheese. Sod cowhouses are within the reach of all who can work.

Second. Keep as many hens as you can take care of. Feed well and protect from coyotes and other beasts of prey. If you can raise turkeys and geese they will pay. Turkeys and geese may be herded by children, and turkeys are the best grasshopper exterminators known.

Third. For field crops on sod, plant early amber cane, yellow Milo maize and corn. The seed used should be grown in the vicinity if possible, if not, choose some early variety. If you are able to do so, prepare a small field for fall wheat.

Fourth. Plant a garden. If you have no well, plant a small plat near the house and water it with the waste water. Bury every drop of waste water beside some vegetable by making a furrow beside the plants and after the water has sunk away fill the furrow with dry dirt. Old tin cans sunk in the ground by the side of hills of cucumbers aid in watering them economically. Punch holes in the bottoms of the cans.

If you have a well, plant a large garden but plant all garden stuff in rows so that it may be cultivated with horse power. Use the water with the same economy that you would if using only waste water. Never flood the ground purposely. If any should be flooded, stir it thoroughly as soon as it is dry enough.

It is a common mistake with beginners in irrigation to try to make water take the place of cultivation. The result is failure. Another

*The writer has fought grasshoppers and drought in Eastern Colorado for many years. Besides early training in Kansas, he was in charge of work on the Plains for the Colorado Experiment Station from 1896 to 1904, as Superintendent of the Sub-station at Cheyenne Wells, and as Field Agent for the Experiment Station. Is now in the employ of the U. S. Department of Agriculture in the Dry Land Division, to be located at Akron, Colo.

common mistake is to plant a larger area than can be watered from the well. Better begin with only a few square rods and extend the area as experience dictates.

In case you cannot irrigate from a well, select a small patch of ground upon which you can turn the flood water from the prairie by means of furrows. If you can make a small reservoir above the patch, do it. The reservoir may hold a few barrels of water until you have time to direct it to the plants which need it. Cultivate thoroughly and keep all weeds down.

Besides the small truck, a good patch should be planted to Mexican beans, early cow peas, watermelons, muskmelons, stock melons, pumpkins, squashes, popcorn, sweetcorn and potatoes. These will sometimes bring good crops without irrigation. Enough should be planted so that a plentiful supply of winter food for the family will be assured. Stock melons are very productive, and if stored in sod buildings, above ground, they will furnish green food for the milch cows during winter. I have grown stock melons at the rate of 20 tons per acre. I have kept ordinary watermelons until the last of November by packing them in hay and storing them in a room where they kept cool but did not freeze. There are varieties of winter watermelons and muskmelons which are good from Christmas until March.

By planting the following seven varieties of sweetcorn on the same day—and often near the last of May—I have had roasting ears from July 26th until September 26th. The varieties were: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentleman, Mammoth Evergreen, and Egyptian. The large varieties may be dried for winter use or allowed to ripen to be used parched. Parched sweetcorn is a luxury, but one which is within the reach of the poorest settler. White Pearl and Queen's Golden popcorn have done well for me, and my family have had many meals consisting only of whipped cream and popcorn.

Potatoes, squashes and pumpkins may be grown successfully by keeping up a constantly successful fight against potato beetles and squash bugs. This means to battle almost daily with the pests from the time the potatoes are up until the middle of August, and from the time the squash plants are up until the squashes are ripe. To describe methods of fighting these pests would require volumes, but we advise you to use your ingenuity in killing them. I preferred to kill them with clubs.

Grasshoppers are the worst enemies to field crops, but by keeping plenty of poultry, the grasshoppers will be kept down.

To produce crops of any kind may require an amount of labor which seems enormously out of proportion to the market value of the produce, but we assume that people who have settled here desire to build up homes and they have come here because they failed to get homes elsewhere. It may be a comforting thing to remember that you may not be working any harder here while trying to establish independence than you would be if working by the day for some one for just enough wages to support yourselves.

CROPS FOR UNIRRIGATED LAND.

BY J. E. PAYNE.

After seven years of experience in Eastern Colorado we feel justified in making some recommendations for the use of those who may try crop raising there without irrigation.

Soils. We have never seen any good crops grown without irrigation upon adobe or very heavy clay soils. But upon sandy loam, sandy and medium and light clay soils, we have seen crops raised on a paying basis nearly every year when given especial attention.

Seeding and Culture. The natural vegetation of the country shows that thin seeding is necessary. The buffalo grasses are thin where they do not get the use of the rain which falls, and thick in locations which catch extra water, as in low lands partly surrounded by hills. All crops should be planted thinly, so that they will not need too much water to make the growth high enough to harvest. All crops should be thoroughly cultivated, so as to give them the benefit of the largest per cent of the rainfall. Thorough and clean culture should be pursued until August 1st, whether rain falls or not, as the crop is thus kept in good condition to use rains which fall late in the season; while if the crops are not kept clean, no amount of cultivation after the late rains will take the place of the cultivation which should have been given before. The most important thing—next to water—is doing the work at the proper time.

Ground intended for planting in May should be thoroughly disced in March or early in April so as to hold the early moisture.

These remarks refer only to crops which are recommended in this bulletin, and to crops usually planted in rows and cultivated.

Crops to Depend Upon. Eastern Colorado is mainly a stock country, and the needs of the country demand rough forage for wintering stock.

We have found that the sorghums and a few acclimated varieties of corn produce paying crops, taking an average of five year's crops as a basis for estimates. Very few of the sorghums ripen seed in Northeastern Colorado, so if one wishes to produce seed of either *corn* or *sorghum,* he should be careful to plant seed which was grown in the vicinity.

The following table gives the most important facts concerning the varieties best known.

Name.	Sweet or Non-Saccharine.	Produces Seed.	Fodder.	
			Quality.	Quantity.
Early Amber	Sweet	Abundantly	Good	Large
Early Orange	"	Sparingly	"	"
Kansas Orange	"	"	"	"
Colman	"	"	"	Medium
Collier	"	"	"	"
Folger's Early	"	"	"	"
Red Kaffir Corn	Non.-Sac.	"	"	"
White Kaffir Corn	"	"	"	"
Jerusalem	"	Abundantly	Poor	Small
Yellow Milo, Maize	"	Sparingly	Good	Medium
White Milo Maize	"	"	"	"
Brown Durra	"	Abundantly	Poor	Small

Broom Corn. Broom corn is usually easily raised. The market price of good brush makes its production profitable or unprofitable and not the amount which can be produced. The fodder and corn always have a ready home market, but broom corn must be sent out of the country.

Mexican Corn. A flint variety grown in Northern Lincoln, Western Kit Carson, and Central Arapahoe counties. Very rich in protein. Some years the ears merely stick out of the ground and the tassels may not be more than two feet high.

There are several other varieties of corn which do well, but they are confined to small neighborhoods and we cannot be sure that much seed could be had.

Planting. Planting should be done with a lister drill. Use from two to five pounds of seed per acre—according to quality of seed.

Cultivation. This should be done as long as possible with the harrow. Then follow with the weeder, and if it seems best, with the cultivator. *Careful* and *thorough* culture must be given. If planted on sod, it may be planted by a special planter drill. If planted on land broken years ago and left unused during recent years, it will not be likely to produce a good crop unless the season is very favorable.

Time of Planting. May 1st to June 10th, according to the conditions. Sorghum does not grow much until warm weather, but it should be planted while the early moisture is in the ground.

With up-to-date tools and plenty of horses one man can plant and cultivate 160 acres in corn or sorghum. He must use gang listers, large harrows and gang weeders in order to do this, but by working in this way the cost of producing feed may be reduced considerably.

The sorghums are as sure to make a paying crop in Eastern Colorado as corn is in Eastern Kansas.

It is the hope of the author that he can help the people to make two steers grow in Eastern Colorado "where one grew before."

DAIRY WORK FOR PLAINS SETTLERS.

H. M. COTTRELL.

Thousands of families are coming to Colorado this spring to locate on farms. Many of them are locating in the dry land sections of the state, often on land on which a furrow has never been turned.

The methods of handling the soil, the varieties of seeds used and the handling of the crops after seeding are entirely different from those found profitable in Eastern States. Experienced men who have farmed in two or more states and under widely different conditions do not expect to meet expenses for crop raising the first year while they are learning what methods and varieties are most profitable in a new location.

Many of our new settlers have a limited amount of capital, and a failure of crops this year would bring suffering to a large number and financial hardship to others.

To those settlers whose means are not sufficient to carry them through a year of crop failure and have sufficient left to grow a crop the second year, we would advise the breaking up of a small area only, not over 40 acres on a quarter section, and if money is quite limited, not over 20 acres .

Write to the Experiment Station, Fort Collins, Colorado, for advice as to the best methods of preparing the soil, the best crops to plant varieties to use and the best method of treating the crops after seeding. This advice will be given gladly and freely.

The new settler should consult the successful farmers who are his neighbors, asking them the same questions that he asks the Experiment Station. Then utlizing the advice from his neighbors and the Station, handle his 20 or 40 acres in such a way as to get the largest yield from them. He will learn more from cultivating this small area well than he will if he puts all the land he can into crops and is obliged to do the work poorly.

While learning how to raise profitable crops under his new conditions, the farmer will need an income to support his family. One of the best ways of securing this is by milkng cows and selling the cream to a factory.

Range cows selected for milking qualities and fed on the native prairie pastures of Colorado alone will produce through the summer from $2 to $5 worth of milk per head a month. All the creameries pay cash at least once a month, and some of them pay daily. The farmer, if he cultivates a small area only, will have the help to milk from 10 to 15 cows, and these will give him a cash income of from $20 to $75 a month, depending on the number and quality of the cows milked.

Selling the cream to the creamery will require much less outlay for building and equipment than will be needed if butter is made on the farm, and will make the work much lighter for the housewife,

whose work is already hard enough when starting in a new home.

The calves should be sold for veal as soon as old enough, and the work saved in not raising them by hand can be put on the crops and in making improveemnts.

The warm separator milk can be fed at a good profit to pigs and poultry, giving another source of cash income to the new settler.

Sorghum should be sown broadcast to be fed in the fall to keep up the flow of milk.

In selecting range cows for dairy work the grade short-horn has been usually found the most satisfactory. The cow should be selected for four dairy points—a good udder, prominent hip bones, a sharp bone at the top of the shoulder and large stomach capacity. The writer selected a carload of range cows along these lines: None of them had been fed grain and several had to be roped before they could be milked. These cows averaged over $40 per head the first year in cream sold to the creamery, and one cow with these points well developed produced $60 worth of cream the first year.

PREPARATION OF SEED BED.

HINTS FOR THE PLAINS.

BY W. H. OLIN.

Crop conditions in Eastern Colorado are so different from crop conditions in the humid region that special attention should be called to them for the benefit of the new settler.

The very best system of tillage may fail to produce a crop some years, but proper soil management and use of acclimated seed adapted to prevailing conditions tend to render crop failures less frequent and harvests therefore more remunerative.

In the farming operations of many parts of Eastern Colorado, where irrigation can not be practiced, the amount of water available to plants is the "limiting condition of success," as Prof. Failyer calls it. Here is found abundance of cheap land, quite fertile, and water is the element that must be most carefully conserved to insure a crop. No rain water must be allowed to run to waste if possible to store it in the soil. Rains on the plains are usually quick dashing rains and the seed should be in such tilth that both upper soil and subsoil will readily absorb the water which falls during the crop season.

The preparation of the seed bed calls for careful plowing, harrowing and sub-surface packing.

Experience demonstrates that the preparation of the soil reservoir (seed bed) of good depth several months before seeding, the thorough culture of the ground before and after seeding, are essentials that very largely determine success in Eastern Colorado. Summer tillage conserves moisture while it renders more plant food available, keeps down weeds, and keeps the soil in good tilth.

Preparing New Ground for Spring Seeding.—It is always a questionable practice to crop newly broken sod in a dry year. The sod usually contains but little moisture and the process of breaking causes one to lose an appreciable portion of it. Suggestive plan: Plow sod land not less than three nor more than five inches deep, turning sod down as flat as possible, and thus prevent its drying out too soon. Follow as closely with disc harrow as practicable, and this with some form of packer, either single or double roll. This will level the sod land above, and firm the soil in the lower portion of the furrow slice, restoring the capillarity where plowing has arrested it. This firmed under-surface soil is thus enabled to draw moisture from below and give good, normal root development. Follow up the packer with either an acme or a good smoothing harrow to produce a good earth mulch to arrest surface capillarity and check evaporation of soil moisture. Follow with the seeder. All small grain should be drilled in with a press wheel drill, followed up with a good spike-toothed or smoothing harrow. It is almost necessary that all tillage operations on sod be with the furrows rather than across them to avoid tearing up the sod and drying out your seed bed. Do not seed broadcast. Make each tillage operation thorough—plowing, disking, firming, harrowing and seeding.

When the new crop is up, cross harrow to prevent the formation of a crust and giving the young crop a cultivation. Follow up each rain with a good harrowing as long as character of crop will permit.

Early in June prepare seed bed for the fall and following spring's seeding. Try to hereafter seed only on ground which has been given "summer culture" treatment.

Remember that roots of all cultivated crops make their best growth when you provide:

A firm mellow
A warm mellow
A ventilated
A moist
} Soil well supplied with plant food.

Methods of farming which (a) conserve the moisture, (b) prepare a good seed bed, (c) reduce the evaporation to as near the minimum as possible, (d) use good vital acclimated seed, (e) employ a crop rotation which has stock foods prominent, contain at least one money crop, (f) and practice thorough tillage of the ground, often tide the farmer over bad years and insure his success in good years.

SUMMER CULTURE TO CONSERVE MOISTURE.

HINTS FOR PLAINS SETTLERS.

BY W. H. OLIN.

Many hundred farmers, unfamiliar with the soil and climatic conditions of our eastern plains, are this year coming to make homes

on 160-acre farms in Eastern Colorado in regions where crops have not been generally grown. Many of these settlers have but a limited amount of money and can not afford a crop failure. It is feared that this spring crop will be only partially successful, since many of them are farming as they did "back home," and are not using drouth-resistant crops of demonstrated value in their farming operations. This timely suggestion is sent out to prevent crop failure in fall seeding. Preparation of seed bed is the most important thing in farming the non-irrigated lands, and as soon as spring crops are in, the new settler should plow and cultivate his field he expects to seed to fall crops, or the following spring's grain.

Summer culture is an essential of the Eastern Colorado farmer's success. The French found some centuries ago that "manoeuvering" the land—causing the particles of earth to change place by tillage—made it more productive. Experiments now show that summer tillage in our semi-arid lands has an added value—it conserves the moisture, while it renders more plant food available. Good results have been obtained in Eastern Washington, Eastern Oregon, Utah, and many sections of Colorado from summer culture of the land every other season. It has been found that in this way sufficient moisture can be stored from the year's rainfall to mature a crop in many localities.

After the snows of winter have melted in the spring, plow the ground at least seven or eight inches deep. With disc harrow, corrugated roller, imperial pulverizer, or packer, level and firm this ground as soon after plowing as possible, at least not later than each half day, and follow up with smoothing harrow to establish the earth mulch to check evaporation. This mulch must not be too fine, as the winds of the plains will tend to rift the soil or blow the earth mulch entirely away. If possible, stir the surface soil with a good spike-tooth or acme harrow several times through the summer from two to four inches deep. Follow every summer rain with a good harrowing of this "summer cultured" ground, preventing the formation of a crust at the surface. Keep this ground clean—free from weeds.

Ground that has been well cultivated for several years will produce two crops in succession and can be given summer culture the third year. In this way it is possible to grow two crops in three years on well-tilled soil. If a farmer expects to cultivate 80 acres, he should divide it into two crop divisions—cropping 40 acres the first year and giving summer culture to the other 40 acres. This gives him a crop on one half his land each year while he is storing up moisture in the soil reservoir of the other half to make the next year's crop. A farmer on the non-irrigated lands in Weld County last season, after seedng his spring crop, at once prepared his fall wheat seed bed—150 acres. The writer visited his field early in July and found his seed bed in a fine mellow, moist, condition for seeding. Just a few miles from this careful farmer's ranch was a 500-acre field which had been simply plowed and left in that condition to dry out and become hard. Although an inch of rain had fallen the week previous, the writer found the soil in this field in very poor mechanical condition—dry and hard.

This clearly shows how not to do. Farmer No. 1 now has a most promising field of wheat and will undoubtedly be rewarded with a satisfactory harvest.

One of the writer's correspondents, living ten miles south of Akron, Colo., has practiced summer culture for several years. He reports that in the fall, when he seeds his summer cultured land, he often finds from three to five feet of moisture.

The writer knows that this method of summer culture has been practiced in some parts of California for upwards of forty years with satisfactory results.

Use every practical method you can to conserve the moisture. Summer culture keeps the ground in good tilth, keeps down weeds, renders the plant food easily available for the next year's crop, while it stores up the moisture so necessary to the plant in assimilating its food.

ACCLIMATED SEEDS.

HINTS FOR NEW SETTLERS IN EASTERN COLORADO

BY W. H. OLIN.

So many settlers, coming from the humid regions of the central states into Eastern Colorado this spring, are bringing with them the seeds of the crops grown "back home," with which they hope to grow crops in a much drier region, that a word of caution is neccessary.

Difference in altitude, amount of rainfall and general climatic conditions urges the writer to warn the new settler that past experience has shown that it will be hazardous to use any but acclimated seeds of such types of grain, forage and root crops as successful farmers of that locality have demonstrated show fairly good drouth resistant power.

Even with the most vital seed of established worth, in some seasons, lack of timely rains jeopardizes a profitable harvest. Last season one Eastern Colorado farmer seeded a drouth resistant strain of wheat, getting twenty-five bushels of good, sound wheat, and in an adjoining field, with the same seed bed preparation and after treatment, he seeded a wheat from another state of unknown drouth resistant power and got seven bushels per acre of inferior quality.

This is further illustrated in every crop grown on the eastern plains of Colorado. Seed, if you will, your choice imported grain in a seed block of an acre or less, but be sure to secure for the general field, grain that is acclmated to semi-arid conditions. The following crops have proven to be reasonably certain in average years for this region:

GRAIN.

Corn.—(An early maturing corn should always be used)
White Australian Flint.
Swadley Dent, and
"Divide" Dent, or Colorado Yellow Dent.

Wheat.—For Spring—
Kubanka Durum.
For fall seeding—
Turkey Red, or
Kharkov.

Barley.—(A bald barley or beardless type, seeded early.)

Rye.—One of the surest crops for hay or grain.

Oats.—This is not a reliable crop every year, but early types, as the Big Four, Kherson, and Sixty Day, acclimated to that region, have given very good harvest for several seasons.

Flax.—This is a new crop to Colorado, and for two years has done well, but its worth has not yet been fully proven. The writer would urge settlers not to seed this crop extensively until it has been more fully tested. If this seed is used, be sure to treat seed with formalin before seeding. The writer will send directions on request. Get Colorado-grown seed, if possible.

Emmer.—(Commonly called speltz.)—A drouth-resistant feed grain.

FORAGE.

Kaffir Corn, Dwarf Milo Maize,
Early Amber Sorghum, and
Proso, are good forage crops.

ROOTS.

Potatoes, where non-irrigated, or "Divide" seed is used, have proven the best root crop in recent years for the plains region.

Seek to grow that crop which will furnish feed, and plan to make some form of meat production the main product of the farm. Get the seed of a few well-tried crops and plan to seed them early, so the crop may get what early spring rains may chance to fall.

Rate of seeding is very important, since seeding too heavily takes up the limited amount of moisture in the ground, causing the whole crop to "fire-burn." Do not seed as heavy as you did in the central or eastern states. The following table may be suggestive, but rate of seeding will vary with manner of seeding, size of seed and condition of seed bed, so no definite rule can be laid down. Do not seed broadcast, if you can possibly drill in the grain.

Rate of Seeding for Eastern Plains.

Grain Crops.	lbs. per acre.
Wheat	30 to 50.
Wheat (Kubanka Durum)	40 to 50.
Barley	35 to 50.
Oats	35 to 50.
Rye	30 to 40.
Emmer or Speltz	35 to 50.
Field Peas	25 to 40.
Proso	6 to 12.
Forage Crops.	
Sorghum	8 to 20.
(Varies with the method of seeding.)	
Alfalfa	15 to 25.
Meadow Fescue	15 to 25.
Brome Grass	15 to 25.
Vetches	18 to 30.

POTATOES ON THE PLAINS.

BY E. R. BENNETT.

Where potatoes can be grown in this State they have proven one of the most valuable of the farm crops. However, little investigation has so far been made of the methods of culture that are best adapted to the conditions under which potatoes must be grown on the unirrigated lands of Eastern Colorado. Some very good crops of potatoes have been grown in this section in the past year or two, and it is thought possible that considerable acreage may be planted this year.

The methods of growing employed and the best varieties to plant are necessarily different from those used in the irrigated districts, so a word of advice to the new comers may be timely.

While it is advisable for every farmer to plant potatoes enough for the use of the family, we would not advise those inexperienced in the business to plant a large acreage at first. An acre or two, if successful, will more than supply the family needs, and, if unsuccessful, comparatively little will be lost.

Varieties and Seed.—One of the first requisites for success in growing potatoes on the plains is to get seed that is adapted to the conditions. Probably the best is that which has grown under similar conditions for several generations. If that is not to be had, seed from the Arkansas divide (Elizabeth)country, or even from Dakota, Minnesota, or Wisconsin will do. Seed from the irrigated lands should not be used.

Usually the early part of the season suffers less from drought than the latter; therefore, the early maturing varieties are generally better for the purpose than the larger late potatoes. Early Ohio and Rose Seedling have been grown in this State with considerable success in the past and are probably safer to use than some of the common Eastern varieties.

Soils.—Potatoes are grown on nearly all kinds of soils, but the lighter soils that will hold moisture are generally to be preferred. Land that has been cultivated should be selected in preferance to raw land.

Preparation of the Land.—Plow the land to a good depth when in good condition to work as early in the spring as possible. Harrow the land as fast as plowed to form a soil mulch and prevent loss of moisture by evaporation. From the time plowing is done till planting time, the land should be frequently harrowed. If rains come, the land should be harrowed as soon after the rain as the land can be worked without puddling the soil.

Planting.—In most cases the earlier the planting can be done without danger of early frosts hurting the vines, the better. When it is possible to do so, use a machine for planting, for by so doing

the seed is put down into moist soil, while hand work is apt to leave seed covered with loose, dry soil, in which case the seed will be delayed in coming up and a poor stand result. If the seed is planted deep (not less than five or six inches), this trouble will be to a certain extent avoided. If machines for planting are not available, the hand potato planter used in the East will do the work fairly well.

With the limited amount of moisture that is available for the crop, the plants will do better if planted at a greater distance apart than is usually practiced. If the hand planter is to be used, the field can be marked out as for corn and planted in rows both ways. If the machine is used, rows from forty inches to four feet apart with hills twenty inches to two feet apart in the row will probably give the best results.

Cultivation.—After the potatoes are planted, the success or failure of the crop will, to a large extent, depend upon the cultivation given.

The first cultivation should be given soon after the potatoes are planted, before the plants are out of the ground. Set the cultivator to run as deeply as possible to loosen and aerate the soil. The cultivator should be immediately followed by the harrow to smooth the surface and re-establish the soil mulch. After the potatoes are up, frequent shallow cultivation should be given till the vines become too large to work.

WIND-BREAKS AND SHELTER BELTS FOR THE PLAINS

BY B. O. LONGYEAR.

Wind breaks, as the term implies, are plantations of trees or similar plants intended to check the force of the wind. They may be used to lessen the drying effects of hot winds in summer to prevent injury or loss to fruit in autumn, and to shut off the cold winds of winter from yards and buildings. Wind-breaks for the last purpose are usually called shelter belts, and are often made several rods in width.

The location of the wind-break will, of course, depend on the direction of the prevailing winds. For general purposes the north and west sides of the area to be protected are the ones along which the trees are planted in most portions of this state. Shelter belts should be planted far enough from buildings so that drifting snows on the inner side will not be an inconvenience.

The simplest kind of wind-break is one formed by planting some one species of tree in a single row. If a tall-growing tree is used alone in this way there is a tendency for the trees to spindle up and in time the trunks lose their lower branches. Such an arrangement may do very well for a time, or where only partial checking of the wind's force is desired. But where more complete shelter

from winds is desired, it is usually necessary to plant several rows of different species, so arranged that the low, dense-growing kinds will fill in the places between the taller ones.

For the taller-growing tree in this region the common cottonwood may be used, setting them about eight feet apart for the outer or north and west rows. A second row of some denser-growing kind should be planted about eight feet from the first and as close as four feet in the row. For this purpose box elder is a suitable tree, except in dry situations, in which case the green ash is recommended. The trees in the third row may be planted the same as in the second row, using a more compact-growing kind. The Russian golden willow is recommended for this purpose as a rapid grower. The Russian wild olive is a more compact tree of lower growth and is particularly desirable. White or American elm is also a suitable tree for the inner rows in many places, especially where a fair amount of moisture can be depended on.

In cases where the wind is exceptionally strong, it may be found necessary to plant a belt four or five rods wide, in order to secure complete protection. The outer two rows may consist of Russian olive, the third and fourth rows of black locust, the fifth and sixth rows of box elder or ash, the seventh and eighth rows of American elm, and the inner two or three rows of cottonwood or Carolina poplar, the rows being about eight feet apart. The golden Russian willow may be used in place of the elm, and honey locust may take the place of the black locust.

The ground should be prepared as carefully as for a crop of grain or sugar beets. Where the rows are to stand, the soil should be furrowed out each way by making a back furrow between each two rows. When harrowed, the land will slope each way toward the trees thus tending to collect drifting snow where it is most needed.

The same care in planting should be taken that would be given in setting an orchard. Seedling trees, two years old, are better in most cases than large ones, as they will bear transplanting more readily, are easily handled, and the cost is much less than with the larger sizes. Trim off all broken and bruised roots with a sharp knife and cut back the top to correspond. Set the trees an inch or two deeper than in the nursery, and firm the soil about the roots.

As soon as planted, irrigate if water is available. If not, give a shallow cultivation to check surface evaporation from the soil.

Cultivation should be continued during the growing season, especially after each rainfall. This is particularly necessary on the plains or where water for irrigation can not be supplied. Such cultivation is calculated to keep a thin layer of fine, dry soil on the surface, which acts as a mulch to conserve moisture. Such care should be continued during the first three to five years, or until the trees shade the ground between the rows. A mulch of old straw at this time may be placed between the rows, and will assist the trees in keeping down the grass and weeds.

Pruning is not desirable, unless it be so done as to cause a thicker growth. Thus in the case of the willow, many smaller stems may be secured by cutting out the main trunk a foot or so above the ground when four or five years old. In this way a single, or, better still, a double row of willows, closely planted, may be used as a hedge, which will also serve as an effective wind-break.

GRASSHOPPERS UPON THE PLAINS.

BY C. P. GILLETTE

The western plains have long been noted for their hordes of grasshoppers. The reputation is chiefly due to the great swarms of the "Destructive" or "Rocky Mountain Locust" that used to fly out from the mountains in numbers sufficient to destroy all crops in a few hours, wherever they stopped. This pest is no longer to be feared in Colorado, but there are several species of locusts (grasshoppers) that are present every year and often in destructive numbers. The habits and remedies for the most of these may be given in a general way as follows:

Life History.—During the fall months the female locusts deposit their eggs in little pockets, an inch to an inch and a half deep, in the ground. The eggs are found in largest numbers along road sides, ditch banks and the borders of fields. They hatch about as soon as green vegetation starts enough to give the little hoppers plenty of tender, nutritious food.

If plenty of food is at hand, the little grasshoppers do not wander far from the place of hatching for a few days, and their presence may be noticed by the perforated and ragged leaves of weeds as well as cultivated plants where they are feeding.

By the middle of July, a few of these locusts will have wings, which means they are fully grown, but few, if any, eggs will be deposited before the middle or latter part of August. Very soon after a female has laid her eggs she dies, and there are some of the later individuals that do not finish egg-laying until they are killed by the cold, freezing nights late in November. There is but one generation or round of development of the locust in a year.

Destruction of Eggs.—The eggs of locusts are very soon killed by being exposed to the dry air and sunshine of Colorado, so if it is known that there are many of the eggs in meadows, alfalfa fields, along road sides or ditch banks, it is an excellent plan to plow or thoroughly harrow the infested ground during the late fall, winter, or early spring. It will pay well to harrow the alfalfa just because of the increased crop of hay that will result, even if there are no locust eggs.

Destroying the Locusts.—The little hoppers, when very abundant about the border of the fields or along ditch banks ,can be largely killed by a thorough spraying with arsenate of lead, 3 pounds to 50 gallons of water, or Paris green, ½ pound to 50 gallons, as for other insects. A narrow strip, not to exceed a rod in width, sprayed early in spring, will not endanger stock eating the hay later on, but care should be used not to put stock upon sprayed areas too soon.

Where straw is available, it may be spread lightly over ditch banks and other places where the hoppers are abundant and be burned In gardens and among potatoes and other vegetables poisoned bran can often be used with success. Mix 1 pound of Paris green with about 40 pounds of bran, add just water enough to moisten the whole, and then sow it broadsast where the hoppers are most numerous. If this poison is used, care must be taken to keep chickens and other domestic animals from the poison for some time.

One of the simplest and often a very effectual remedy is to grow plenty of chickens and turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

Hopper "dozers" or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112.

I shall always be glad to receive inquiries concerning insects that are doing damage in any part of the State. Send specimens of the insects when possible, with samples of their injuries.

RAISING HOGS ON THE PLAINS.

BY H. M COTTRELL.

Farmers living in the Plains regions of Colorado will find it advantageous to give special attention to the raising and fattening of hogs.

The surest grain crops under the dry land farming are barley, wheat, milo maize and Kaffir corn, all four are good feeds for the production of pork.

Barley is the best of all grains for the production of pork of fine quality and flavor. It requires less water to mature a crop than any of our other common grains, and when seeded early is the surest grain crop on the Plains. Many growers on the Plains report an average yield of 2,000 pounds of barley an acre, and this is sufficient to produce over 400 pounds of gain when fed to hogs.

Wheat will produce as much pork as the same weight of corn, and many farmers have found it profitable where rainfall is limited

to raise Durum wheat and fatten hogs with it. Wheat does not produce pork of the first quality and it is best to feed barley the last 30 days of fattening, as it makes the pork finer, the fat whiter, and greatly improves the flavor.

Rye is profitably fed in some sections. It will make good gains, but the hogs should be finished on barley.

Milo maize and Kaffir corn will produce about 90 per cent. of as much gain on hogs as will an equal weight of corn, and are very profitable grains to raise for feeding hogs. Both of these grains are constipating and need some laxative feed to be given with them. Alfalfa hay is one of the best feeds for this purpose, sorghum hay is good, as are also any kind of roots.

Hubbard squash is an excellent feed for fattening hogs and some Colorado farmers use it as an exclusive feed for this purpose, but better gains and finer quality of pork will be secured when some grain is given with it.

A mixture of two grains will give larger gains than the same weight of one grain fed alone.

Dairying is one of the surest and most profitable lines of farming on the Plains, and skim milk fed with grain to pigs and hogs is one of the best of feeds. Hog raising increases the profitableness of dairying.

Grain is high-priced in most sections of Colorado, and while a hog should have some grain every day of his life, at least half the weight of a 200-pound hog should be made from roughage—pasture or fodder. The best pasture is alfalfa, and there are few farms on the Plains but what have some spot where alfalfa will thrive if proper methods are followed, and seed from non-irrigated land is used.

Dwarf Essex rape stands drought fairly well if seeded as soon as the frost is out of the ground. Winter wheat and rye make good early pasture, and sorghum may be seeded in the spring in fields of rye or wheat and will furnish pasture after the grain has dried up.

Good alfalfa hay is the best winter roughage to feed hogs. It can be fed in a rack and will increase the gains and improve the flavor of the pork. In a test made by the writer, hogs fed all the grain they would eat gained 400 pounds, while those fed alfalfa hay and grain gained 600 pounds.

Where alfalfa hay is not available good, juicy, sorghum fodder improves the thriftiness of hogs and increases the gains.

Hogs should have access to salt and charcoal or coal at all times, and wood ashes are beneficial. Good water plentifully supplied is as essential in making gains as is grain.

The Plains section of Colorado has great advantages for raising hogs. The grains most profitable to grow there produce finer flavored pork than corn, and usually the grain can be marketed at a higher price when fed to hogs than when sold on the market. This is especially true where the quality of the grain is inferior.

Denmark sells eighteen million dollars worth of bacon a year to England alone. The Danish bacon sells for a considerably high

price than the best quality of corn fed bacon. The Danish bacon is made from barley-fed hogs.

TYPES OF MILLING WHEAT FOR THE PLAINS.

BY W. H. OLIN.

Winter Wheat.—The Plains farmer has found in the past that wheat is to him a desirable cash crop and when acclimated seed of wheat types having known drouth resistant power, is used, the probabilities for harvest are increased.

The type of winter wheat which for the past five years has been giving best results is Turkey Red. It has a medium straw, a medium to short spike, a small kernel, but is recognized as one of the best of milling wheats. Nearly every mill in the state is ready to pay from 5 cents to 10 cents premium for this wheat, so it has a strong local trade, insuring farmers a good market for the threshed grain. This grain should be seeded on good summer cultured ground at such a time after the middle of September and before the middle of October, as local conditions render advisable. When moisture conditions are such that his wheat gets a good start before it goes into the winter, it has a stem and root growth which enables it to more readily withstand winter conditions and the desirable strength in the spring for sturdy growth. An appreciable amount of winter moisture is very desirable for this crop.

Early fall and late spring rains are essential for a fully developed crop and a satisfactory harvest. Use acclimated seed if possible. Some careful farmers in the vicinity of Holyoke, Vernon, Bennett, Byers and other localities of the Plains, have raised creditable winter wheat this past season, and the writer will be glad to assist, as far as possible, the new settler to get good quality acclimated seed grown under his local conditions.

When the seed bed is well prepared under summer culture conditions, good vital, acclimated seed is properly drilled in the seed bed, (do not broadcast) at least three weeks before the close of the growing season, the farmer has done his part well. This should be followed by cross-harrowing in the spring. This gives cultivation to the growing wheat and thereby invigorates it.

Get and keep pure quality seed.

Spring Wheat.—Kubanka Durum for the past four years has shown itself to be our most drouth-resistant spring wheat for the Plains. While Colorado millers have not used it very extensively for milling, several export dealers are lending encouragment to the growing of this grain, and an increasing export trade east and south seems assured. Besides, this grain is being utilized by many farmers, mixing it with other grains for feeding purposes.

It is our very best poultry food, and crushed and soaked with barley or rye, makes a very good hog food.

This wheat, when made into flour, furnishes a rich, nutritious flour, bread made from which has a rich, creamy color, a nutty flavor, holds moisture longer than bread from the common spring wheat flour, and tests made by the writer show that very satisfactory bread, biscuits and pastry can be made from straight Durum flour.

A few Kansas and Colorado millers are successfully milling this wheat, and should Plains settlers call for and use this flour, the growing and milling of Durum wheat on the Plains will be greatly encouraged.

There are fifteen types of Durum wheat grown in this country. Some types have little or no milling value. White Kubanka Durum (the type recommended for the plains) *will make good quality flour,* and also superior macaroni. This wheat should not be grown under irrigation where a hardy winter wheat has proven itself a well-acclimated grain. It is recommended for those regions of the Plains of Colorado where other wheats are not successfully grown. It is one of our most drouth-resistant spring grains, but is heavily bearded. Colorado No. 50 wheat and White Sonora are showing fairly good drouth-resisting power, but not equal to Kubanka Durum. Both of these are beardless types of spring wheat.

Seed your spring wheat on a well prepared seed bed as early as weather conditions will permit. The earlier seeded, usually the better the grain starts, and it is more likely to blossom and fill before the drying winds come to check development.

Plains farmers are urged to grow their own *bread,* as well as *meat,* and thus "Keep the wolf from the door."

RAINFALL ON THE PLAINS.

BY L. G. CARPENTER.

In some current discussion it seems to be forgotten that all moisture must come ultimately from the rainfall, and, therefore, unless increased by drainage or other source, the amount available for crops must be limited to the amount of rainfall or by the amount absorbed which is considerably less. While land favorably situated may have an advantage from its location, and derive water from neighboring land, there is no method of cultivation which will manufacture moisture. The most to be expected is to lessen the losses, by evaporation and otherwise, which normally take place, and possibly to take advantage of favorable location. In depressions or valleys, some water may be received, none the less important because invisible and underground, usually the drainage from higher land. In such locations, the crop may use much more than the local rainfall, hence where crops are

grown below a ditch, they may receive additional waters no less effectively than by surface irrigation. To say they are raised by the natural rainfall is misleading, to say the least.

Many inquiries are asked concerning the amount of rainfall on the plains, and some misunderstandings are prevalent. These may best be answered by giving the records of a number of places where the rainfall has been measured for a series of years. Those which have the longest record are chosen.

To interpret the rainfall records, the distribution and character of the rainfall must be taken into account as well as the amount. It scarcely needs to be said that a moderate rainfall which falls mostly in the growing season, without long intervals between rain, moderate showers, is far more effective than a large rainfall coming principally in the cold season, or which comes in heavy showers at irregular and infrequent intervals. Sudden and heavy downpours are of little agricultural value for the effectiveness of a rain is largely measured by the amount which the soil absorbs and this absorption takes place at a slow rate, varying with the soil, but, say, one-tenth inch per hour. Showers of a few hundredths of an inch are of little value, for they penetrate only the surface of the soil, evaporate almost immediately, and thus are of practically no benefit. Hence moderate rainfalls, well distributed, during the growing months, are of the greatest value. A favorable feature of the distribution of the rainfall in Colorado, is that nearly 50 per cent comes in these growing months. On the divide between the Arkansas and the Platte rivers, more falls in the summer months of July and August. Speaking generally in respect to the plains, the storms of long continuance are mostly in the months of April and May or perhaps the early part of June and October, while the intermediate months of the summer have their precipitation principally in the form of thunder showers.

Even the average rainfall for any given month may in itself be misleading, and especially where the rainfall is moderate or small, and subject to occasional violent storms. The average may be far from indicating the probable quantity to be expected. More than half of the years will be below the average. A better index to the agricultural value of the rainfall is to know the certain surety of a given rainfall which can be depended on. We may take the record of April at Fort Collins to illustrate the difference. While the average for 25 years is 2.31 inches, the record shows that practically three out of four years (18 out of 24) have been below the average. Hence so far as this is a guide for the future, the probability is about three to one that in any given April, the rainfall will be below the average.

If, however, we count the Aprils with reference to the amount, we find that, for a quantity of about 1.44 inches, half of the Aprils have been above and half below. This amount is the safer guide of what to expect. For lack of a better term, I have called this the agricultural mean as distinct from the ordinary average, and it is indicated at the foot of the table. Where there is little difference

between the average and the agricultural mean, it indicates that the rainfall in the month is quite certain.

The records which are given in connection with this bulletin are the records of the stations which have maintained the records for the longest period of time. These include Fort Collins and Denver, on the plains within a few miles of the foothills, and both at an elevation of practically 5,000 feet. Rocky Ford is in the Arkansas Valley about sixty miles east of Pueblo, at an elevation of 4,176 feet. Leroy, (elevation 4,380 feet), Wray, (elevation 3,531 feet) and Yuma, (elevation 4,147 feet), are in Northeastern Colorado; Cheyenne Wells in the Eastern Central (elevation 4,279 feet), and Hamps on the divide between the Arkansas and Platte rivers. The length of record of these stations ranges from 11 to 37 years.

A critical examination indiactes that when changes occur at one station they generally indicate a corresponding change at other stations, but that the increase or decrease is not the same. This is due to the fact that while there are many storms which are general in character, there are also local storms which affect a lesser area. Generally speaking, the rainfall decreases for some distance from the mountains on the plains, and then increases toward the eastern border of the state. It increases with elevation, and prominent ridges, like the divide between the Arkansas and Platte rivers, show an increase or change in the character of the distribution, which materially helps the availability of the supply.

While it is not safe to conclude that the rainfall of the whole eastern part of the state has increased becase the percipitation at one station has increased, yet generally, there is some parallelism.

An examination of the table indicates a marked increase in all the stations for 1905 and 1906 over the average for a period of years. This is shown by the following summary:

Place.	No. Years on Record.	Average.	1905.	1906.	1907.
Denver	37	13.37	17.68	16.84	11.83
Fort Collins	27	14.92	19.86	19.88	11.64
Wray	11	19.25	22.43	23.09	14.23
Hamps	14	14.56	23.60	19.07	10.56
Yuma	16	17.77	23.76	20.76	13.53
Leroy	17	16.06	22.18	21.80	16.57
Cheyenne Wells ...	16	16.58	18.31	19.46	9.72
Rocky Ford	18	13.15	14.39	14.66	13.59
		125.66	162.21	155.56	101.67

The tables give the monthly rainfall. At the bottom is given the average for the whole period of the record. Manifestly in comparing the percipitation in two different stations, it is important that the same years be considered at both placs, or the same months. These tables were made up in the summer of 1907 and thus 1907 was omitted. For convenience, it is given in a separate table by months, but not used in determining the averages or agricultural mean.

PRECIPITATION AT DENVER, COLORADO. *U. S. Weather Bureau*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1870	1.80	1.70	0.70	2.80	0.34	0.52	0.51	0.12	2.85	0.68	0.54	0.73	13.29
1871	0.46	0.23	1.81	1.01	2.56	0.05	0.51	0.27	1.18	0.40	3.10	0.77	12.35
1872	0.55	0.22	1.71	2.09	3.74	2.07	2.69	1.75	1.57	0.68	0.69	0.29	18.05
1873	0.13	0.24	0.22	2.43	0.75	2.24	2.00	1.41	0.89	0.73	0.16	0.61	11.81
1874	0.84	0.53	0.49	1.70	2.43	1.21	3.35	0.68	1.34	0.64	0.08	0.17	13.46
1875	0.38	0.60	0.39	2.24	1.94	0.43	4.32	1.97	2.89	0.22	1.28	0.59	17.25
1876	0.21	0.11	1.80	1.22	8.57	1.10	1.16	2.03	0.60	0.12	1.50	1.70	20.12
1877	1.90	0.40	1.40	2.77	2.30	1.93	0.23	1.30	0.38	2.15	0.73	0.79	16.28
1878	0.10	0.48	1.82	0.05	2.90	2.78	1.38	2.25	1.23	0.80	0.67	1.05	15.51
1879	0.40	0.39	1.00	2.62	3.36	0.32	0.64	1.38	0.02	0.19	0.21	0.33	10.86
1880	0.38	0.32	0.21	0.31	1.11	1.22	1.38	1.46	0.89	1.37	0.83	0.10	9.58
1881	0.49	1.22	0.87	0.50	2.21	0.09	2.50	2.33	0.57	0.32	1.68	0.00	12.78
1882	0.57	0.20	0.20	1.47	2.98	4.96	0.66	1.20	0.06	0.75	0.71	0.73	14.49
1883	2.35	0.45	0.21	3.10	4.30	0.85	2.27	0.75	1.08	1.49	0.32	2.32	19.49
1884	0.22	0.86	0.93	3.33	4.61	1.47	0.65	1.71	0.13	0.21	0.19	0.76	15.07
1885	0.41	0.75	0.97	4.94	2.13	0.66	1.33	1.18	1.22	0.73	0.55	1.08	15.95
1886	0.62	0.72	2.36	2.79	0.09	2.26	0.50	1.62	0.98	0.33	1.93	0.87	15.07
1887	0.67	0.30	0.23	2.16	1.13	0.53	2.49	2.68	0.97	0.97	0.22	0.14	12.49
1888	0.11	0.37	1.15	1.71	2.66	0.29	0.41	1.51	0.11	0.77	0.33	0.09	9.51
1889	0.50	0.70	0.40	1.34	3.44	1.88	2.94	0.33	0.28	2.11	0.53	0.30	14.75
1890	0.18	0.46	0.35	2.50	2.01	T	0.79	1.89	0.17	0.64	0.30	0.04	9.33
1891	1.60	0.27	3.10	2.49	4.15	2.93	0.59	2.84	0.73	0.48	0.69	1.56	21.43
1892	0.40	0.75	1.20	1.75	2.14	1.33	1.19	0.58	T	3.92	0.44	1.32	15.02
1893	0.05	0.83	0.23	0.87	3.09	0.13	1.14	0.35	0.05	0.84	0.55	0.35	8.48
1894	0.18	0.90	0.70	3.30	3.00	0.39	2.11	1.86	1.55	0.19	0.22	0.69	15.09
1895	0.32	0.48	1.19	1.19	2.86	2.65	4.28	0.76	0.98	1.13	0.27	0.01	16.12
1896	0.25	0.24	1.43	0.93	1.27	0.89	2.80	0.97	1.81	0.84	0.10	0.31	11.84
1897	0.58	0.82	0.90	1.31	3.15	2.16	2.06	1.44	0.44	1.64	0.24	0.63	15.37
1898	0.20	0.68	0.28	1.20	4.88	0.94	0.67	0.96	0.28	1.05	0.85	0.99	12.98
1899	0.65	0.58	1.10	0.75	0.15	0.47	1.92	1.78	0.20	1.01	T	0.72	9.33
1900	0.13	0.55	0.63	8.24	0.53	1.87	1.30	0.05	0.87	0.33	0.37	0.42	15.29
1901	0.05	0.06	0.88	1.96	1.18	2.09	0.01	1.30	0.22	0.46	T	0.89	9.10
1902	0.17	0.38	0.63	0.60	1.98	1.89	1.24	0.76	3.70	0.80	0.61	0.59	13.35
1903	0.12	0.42	0.87	0.81	0.75	1.62	1.36	1.35	0.56	1.34	0.07	0.23	9.50
1904	0.04	0.17	0.94	0.74	3.27	3.54	2.13	0.60	1.77	0.40	0.04	0.41	14.05
1905	0.99	0.35	3.07	4.95	2.65	0.61	1.55	0.67	0.49	2.31	0.04	T	17.68
1906	0.17	0.06	1.88	3.67	1.45	1.51	1.21	0.88	2.72	1.98	1.30	0.01	16.84
Average 37 years	0.52	0.51	0.97	2.10	2.49	1.40	1.57	1.27	0.97	0.95	0.60	0.61	13.96
Average 20 years	0.37	0.47	1.06	2.12	2.28	1.38	1.61	1.18	0.89	1.16	0.36	0.49	13.37
Max.	2.35	1.70	3.10	8.24	8.57	4.96	4.28	2.68	3.70	3.92	3.10	2.32	.....
Min.	0.04	0.06	0.21	0.05	0.09	T	0.01	0.05	T	0.19	T	0.00	.....
Agr. Mean	0.38	0.45	0.90	1.75	2.43	1.22	1.33	1.30	0.87	0.75	0.44	0.59	12.41

PRECIPITATION AT AGRICULTURAL COLLEGE, FORT COLLINS, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.02	0.20	.....
1873	0.25	0.16	0.00	1.20	2.30	1.50	1.30	0.85	0.75	0.42	0.20	0.17	9.10
1874	0.06	0.43	1.29	0.77	2.95	0.65	3.15	0.25	0.00	1.00	0.02	0.00	10.57
1879	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.75	0.15	0.60	.....
1880	0.72	1.09	0.38	0.94	0.60	0.86	1.80	0.37	1.47	2.07	1.10	0.10	11.50
1881	1.10	0.55	1.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	.....	.....	0.17	.....	4.67	3.07	1.76	0.89	2.51	0.82	0.29	.....	.....
1883	1.00	1.50	0.68	.....	2.51	3.18	.....	1.78	1.00	1.29	T	1.33	.....
1884	1.10	0.70	1.15	3.94	4.84	.....	.....	.....	.....	0.10	1.80	0.35	.....
1885	1.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.69	1.18	0.33	.....
1887	0.86	0.23	0.25	1.10	1.23	1.96	3.05	2.12	0.54	0.43	0.15	0.00	11.92
1888	0.29	0.36	0.73	1.23	3.39	0.47	0.60	1.01	0.29	0.88	0.38	0.16	9.79
1889	0.21	0.34	0.65	2.07	3.39	2.06	0.79	0.95	0.42	3.16	0.43	0.01	14.48
1890	0.13	0.21	0.22	3.92	1.19	0.12	1.27	3.14	0.07	0.70	0.32	0.12	11.41
1891	2.32	0.16	1.20	2.14	4.07	1.30	0.17	2.05	1.02	0.20	0.60	0.46	15.70
1892	0.60	1.29	1.52	1.60	4.83	2.42	1.32	0.22	0.14	0.93	0.23	0.35	15.45
1893	0.02	0.54	0.14	1.66	1.92	0.26	0.64	0.92	0.18	0.16	0.55	0.12	7.11
1894	0.25	0.60	0.67	0.89	3.09	0.42	1.72	1.53	2.29	T	0.14	0.76	12.36
1895	0.24	1.52	0.54	1.36	3.62	3.65	3.75	1.45	0.47	1.06	0.40	0.01	18.07
1896	0.43	0.03	1.73	1.26	1.68	3.05	3.05	2.20	1.55	0.49	0.05	0.24	15.76
1897	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
1898	0.14	0.08	0.50	1.08	3.65	1.37	0.50	0.98	0.50	0.82	1.24	0.17	11.03
1899	0.66	1.04	1.50	1.10	1.01	1.03	4.95	0.99	0.21	3.23	T	0.47	16.19
1900	0.25	1.12	1.07	10.56	1.75	0.82	1.14	0.16	1.92	0.24	0.07	0.11	19.21
1901	0.19	0.38	1.88	3.62	7.47	2.35	0.71	0.72	2.10	0.36	0.02	1.37	21.17
1902	0.32	0.15	1.50	0.61	2.13	2.43	1.31	0.67	7.12	1.15	0.27	0.77	18.43
1903	0.16	1.60	1.03	1.50	0.63	2.23	1.06	0.86	0.87	1.70	0.18	0.07	11.89
1904	0.04	0.34	0.51	0.89	5.37	1.68	1.99	0.71	1.09	0.39	0.00	0.12	13.13
1905	0.29	0.35	1.75	6.32	4.13	0.64	2.18	1.25	0.28	2.60	0.07	T	19.86
1906	0.01	0.03	2.44	4.30	2.40	1.80	1.96	0.80	3.08	1.59	1.35	0.12	19.88
Average	0.50	0.59	1.00	2.31	2.96	1.64	1.78	1.14	1.22	1.04	0.41	0.33	14.92
Average 20 Years	0.38	0.55	1.10	2.43	2.95	1.58	1.74	1.22	1.24	1.04	0.36	0.34	14.93
Max.	2.32	1.60	2.44	10.56	7.47	3.65	4.95	3.14	7.12	3.23	1.35	1.37	.....
Min.	0.01	0.03	0.14	0.61	0.63	0.12	0.50	0.16	0.07	T	O	0.00	.....
Agrl. Mean, 20 Years	0.24½	0.34½	1.05	1.44½	2.74½	1.68½	1.31½	0.98½	0.64½	0.78½	0.25	0.14	11.63

Observers—1880, F. J. Annis; 1881, A. E. Blount; 1882-5, C. F. Davis; 1886-7, R. Mead; 1888-1906, L. G. Carpenter, R. E. Trimble, Assistant.

PRECIPITATION AT WRAY, YUMA COUNTY

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890	.....	.....	T	T	4.44	1.42	0.62	0.25	1.09	0.45	0.25	T	.....
1891	1.80	0.50	1.90	4.68	2.02	4.55	2.52	0.45	1.24	O	0.20	0.83	20.69
1893	.....	.....	.....	0.03	2.12	1.00	.....	.....	.....	.....	.....	.....	.....
1895	.....	.....	.....	.....	.....	.....	.....	.....	.....	T	0.12	0.32	.....
1896	0.47	0.02	0.66	4.83	1.64	3.77	1.13	1.47	1.01	1.37	0.06	0.20	16.63
1897	0.28	0.26	1.79	1.64	3.34	4.79	1.79	2.27	0.73	2.92	0.07	0.31	20.19
1898	0.06	0.07	0.83	1.73	5.47	2.98	1.88	2.56	2.33	0.25	0.26	0.29	18.71
1899	0.63	0.07	0.50	0.62	1.96	1.83	2.18	1.38	0.08	T	1.16	0.33	10.74
1900	0.16	0.90	0.33	6.00	0.61	2.35	4.57	2.60	0.15	0.03	0.20	0.34	18.24
1901	T	1.37	2.51	4.02	0.28	3.40	2.05	5.36	2.11	0.43	T	0.91	22.44
1902	0.20	0.74	1.05	0.74	7.00	5.69	3.33	2.71	3.73	1.05	0.16	0.59	26.99
1903	0.25	1.98	0.16	0.54	1.95	1.55	5.16	1.48	0.69	0.34	0.25	T	14.35
1904	T	0.58	0.04	2.46	2.02	6.25	2.00	1.26	1.74	1.19	0.05	0.20	17.79
1905	0.04	0.05	3.10	5.12	2.59	3.19	2.98	0.93	2.19	1.64	0.60	T	22.43
1906	0.55	0.62	1.88	4.82	3.20	2.57	1.62	3.57	1.71	1.43	0.83	0.29	23.09
Means	0.24	0.61	1.17	2.96	2.73	3.49	2.61	2.33	1.50	0.97	0.33	0.31	19.25
Agrl. Mean	0.20	.58	.83	2.46	2.02	3.19	2.05	2.27	1.71	1.05	0.20	0.26	16.82
Max. for Month	0.63	1.98	3.10	6.00	7.00	6.25	5.16	5.36	3.73	2.92	1.16	0.91	.....
Min. for Month	T	0.02	0.04	0.54	0.28	1.55	1.13	0.93	0.15	T	T	T	.....

Established by the Colorado State Weather Bureau. Observer—J. C. Tuomey.

PRECIPITATION AT HEMPS, ELBERT COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1893	0.02	0.08	0.02	0.24	1.60	0.70	3.07	1.23	0.27	0.16	0.04	0.19	7.62
1894	0.07	0.29	0.54	1.11	4.10	0.51	1.65	1.23	1.19	0.05	0.02	0.17	10.93
1895	0.15	0.42	0.28	0.85	2.05	3.79	4.07	2.08	0.12	0.15	0.10	0.11	14.70
1896	0.52	0.30	1.25	1.22	1.05	0.70	3.42	2.80	0.65	0.57	0.02	0.28	12.78
1897	0.14	.....	.....	0.49	0.70	1.68	1.35	6.21	0.42	0.96	T	0.22	.....
1898	0.04	0.02	0.20	0.96	3.80	1.03	1.84	1.61	1.17	0.90	0.28	0.72	12.57
1899	0.90	0.19	2.26	1.30	0.30	1.13	2.50	2.19	0.19	0.49	0.51	0.71	12.67
1900	0.09	0.60	0.86	11.30	1.25	2.20	1.94	0.91	0.65	0.09	0.25	1.03	21.17
1901	0.34	0.07	1.50	4.24	0.83	0.98	0.38	2.58	0.52	0.81	T	0.69	12.89
1902	0.23	0.13	1.37	1.03	4.97	2.52	0.62	2.68	1.37	0.91	0.22	0.98	17.03
1903	0.20	0.76	0.21	0.53	0.75	3.73	1.99	1.40	0.44	0.53	0.09	0.14	10.77
1904	0.03	0.07	0.06	0.71	3.08	2.70	2.69	3.09	2.37	0.62	T	0.09	15.51
1905	0.08	0.58	3.48	4.86	3.98	2.04	4.72	1.27	2.23	0.23	0.13	T	23.60
1906	0.38	0.90	2.25	4.17	0.98	1.44	3.09	2.56	2.23	0.64	0.38	0.05	19.07
Mean	0.23	0.32	1.10	2.35	2.10	1.79	2.38	2.27	0.98	0.51	0.15	0.38	14.56
Agril. Mean	0.14½	0.29	0.86	1.16½	1.42½	1.56	2.24½	2.13½	0.65	0.55	.11½	.20½	11.34
Max. for month	0.90	0.90	3.48	11.30	4.97	3.73	4.72	6.21	2.37	0.96	0.51	1.03	.....
Min. for month	0.02	0.02	0.02	0.24	0.30	0.51	0.38	0.91	0.12	0.05	T	T	.....

Established by U. S. Weather Bureau. Observer—W. Hamp.

PRECIPITATION AT YUMA, YUMA COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	2.35	0.50	3.63	2.90	4.21	5.23	2.98	0.75	0.64	0.05	0.13	1.25	24.62
1892	0.80	1.55	0.80	3.20	3.46	1.20	4.44	1.50	0.35	1.00	T	0.62	18.92
1893	T	0.90	0.70	0.38	2.57	1.30	2.10	0.95	T	0.40	0.41	0.55	10.26
1894	0.50	0.90	1.10	0.68	0.04	1.85	0.80	0.70	2.85	O	0.22	0.70	10.34
1895	1.20	1.70	0.50	1.10	2.76	2.73	3.22	1.77	0.55	0.10	0.60	0.10	16.33
1896	0.60	0.20	1.25	1.82	2.06	3.98	2.59	1.04	1.02	0.78	0.30	0.20	15.84
1897	0.37	0.40	2.80	0.80	1.62	4.44	1.78	2.44	T	2.55	0.10	1.00	18.30
1898	0.30	0.20	0.31	1.55	5.80	2.70	1.86	3.62	1.00	1.50	1.45	1.10	20.39
1899	1.38	0.60	1.18	0.97	1.23	3.03	2.63	2.22	0.17	0.03	0.90	0.27	14.61
1900	0.14	1.55	0.61	8.67	1.39	0.72	1.81	2.22	0.16	0.03	0.17	0.51	17.98
1901	T	1.11	2.44	3.90	0.31	3.51	1.61	6.53	0.36	0.39	T	0.57	20.73
1902	0.07	0.56	0.95	0.67	3.76	1.91	2.70	3.33	1.68	0.78	0.20	0.73	17.34
1903	0.14	1.88	0.20	0.40	1.00	2.10	2.65	3.12	0.35	0.10	0.36	0.09	12.39
1904	T	0.70	0.25	3.37	4.26	4.98	1.65	1.28	2.92	1.07	T	0.27	20.75
1905	0.31	0.13	4.47	4.27	3.64	2.16	4.45	0.73	1.91	1.64	0.05	O	23.76
1906	0.38	0.51	2.36	4.45	2.01	1.98	2.44	1.23	1.19	2.92	1.17	0.12	20.76
Means	0.53	0.84	1.47	2.45	2.51	2.74	2.48	2.09	0.95	0.83	0.38	0.50	17.77
Agril. Means	0.34	0.65	1.02½	1.68½	2.31½	2.43	2.51½	1.63½	0.59½	0.59	0.21	0.53	14.52
Max. for month	2.35	1.88	4.47	8.67	5.80	5.23	4.45	6.53	2.92	2.92	1.45	1.25	.....
Min. for month	T	0.13	0.20	0.38	0.04	0.72	0.80	0.70	T	O	T	O	.....

Established by the Colorado State Weather Bureau. Observer—Geo. W. Custer.

PRECIPITATION AT LE ROY, LOGAN COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	.....	.....	.....	4.40	2.09	3.38	0.36	2.56	0.83	0.37	0.60	0.10	.....
1890	0.30	0.48	0.01	2.80	1.03	1.96	0.47	1.41	T	0.98	0.48	0.01	9.93
1891	1.70	1.00	1.99	1.35	5.02	4.84	4.69	2.89	0.67	0.14	0.37	0.94	25.60
1892	0.89	2.24	0.80	4.02	2.53	1.48	3.07	1.83	0.84	1.66	0.10	0.65	20.11
1893	0.05	1.20	0.87	0.46	2.73	1.25	1.75	0.61	0.41	0.41	0.48	0.94	11.16
1894	0.35	0.46	0.95	0.98	0.17	0.75	1.16	0.47	1.06	0.08	0.26	0.65	7.34
1895	0.73	0.88	0.40	2.43	2.05	2.94	2.56	0.79	0.42	0.11	0.47	0.12	13.90
1896	0.53	0.24	1.20	1.91	2.36	3.77	1.33	0.87	0.86	0.90	0.20	0.01	14.18
1897	0.60	0.72	1.66	1.77	3.08	2.24	1.39	2.79	0.41	2.61	0.40	0.81	18.48
1898	0.38	0.26	0.67	1.07	4.60	1.31	2.83	1.13	1.27	0.54	0.65	0.27	14.95
1899	0.50	0.33	1.21	1.57	2.93	0.28	2.17	2.38	0.88	0.30	0.23	0.44	13.22
1900	0.10	0.96	0.12	7.27	2.10	0.78	1.68	0.99	0.35	0.07	0.12	0.20	14.74
1901	0.06	0.49	1.60	2.92	0.72	2.52	0.97	4.03	0.27	0.47	T	0.89	14.94
1902	0.12	0.72	1.23	1.28	3.16	1.82	0.98	3.70	3.46	0.78	0.09	0.99	18.33
1903	0.18	1.50	0.26	1.12	0.80	1.07	1.71	3.44	0.62	0.29	0.06	0.03	11.08
1904	0.10	0.26	0.35	1.99	3.97	4.39	3.46	1.17	2.96	1.55	0.04	0.05	20.29
1905	0.17	0.30	3.28	4.70	3.88	2.48	2.56	1.96	0.78	1.93	0.12	0.02	22.18
1906	0.23	0.43	1.38	4.53	1.96	1.35	1.88	2.83	2.70	2.69	1.29	0.53	21.80
Means	0.41	0.73	1.06	2.59	2.51	2.14	1.95	2.00	1.04	0.88	0.33	0.42	16.06
Agril. Mean	0.23	0.49	0.95	1.95	2.44½	1.89	1.81½	1.89½	.80½	.50½	.24½	.35½	13.58
Max. for month	1.70	2.24	3.28	7.27	5.02	4.84	4.69	4.03	3.46	2.69	1.29	0.99	.....
Min. for month	0.05	0.24	0.01	0.46	0.17	0.28	0.36	0.47	T	0.07	T	0.01	.....

Established by the Agricultural Experiment Station. Observer—Charles Green.

PRECIPITATION AT ROCKY FORD, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	0.36	0.12	0.67	2.12	1.75	0.75	4.50	1.28	0.26	1.68	0.77	0.04	14.30
1890	0.34	0.15	0.15	2.97	0.29	0.77	1.14	0.74	0.08	0.00	0.30	0.00	6.93
1891	1.50	0.00	1.80	0.43	3.52	2.31	0.74	0.73	1.75	0.21	0.20	1.77	14.96
1892	0.50	0.80	1.50	0.73	3.26	3.31	1.99	3.10	0.00	0.95	0.50	0.46	17.10
1893	0.02	0.08	0.80	0.25	0.70	0.40	10.26	3.20	0.30	0.25	T	0.50	16.76
1894	0.10	0.95	0.45	0.60	4.25	0.70	1.40	0.25	0.80	0.00	0.04	0.65	10.19
1895	0.27	0.65	0.07	0.35	1.90	0.52	4.87	1.86	T	0.85	0.20	0.57	12.11
1896	0.32	0.18	0.23	0.55	1.12	0.47	2.09	0.47	1.85	1.96	0.00	0.70	9.94
1897	0.75	0.37	0.20	0.44	.....	.....	.....	0.73	0.79	2.64	0.19	1.06	.....
1898	0.40	0.00	0.16	1.06	2.71	3.16	3.52	0.92	1.55	1.36	0.37	0.96	16.17
1899	0.98	0.55	0.32	0.28	0.99	0.78	7.00	2.22	1.43	0.63	2.40	0.98	18.56
1900	T	0.52	0.37	7.15	2.28	1.47	1.77	1.05	0.08	0.60	0.06	0.24	15.59
1901	0.20	0.10	1.00	2.36	1.34	0.23	1.48	0.74	0.48	0.25	0.00	0.50	8.68
1902	0.18	0.57	1.78	0.18	4.02	0.60	0.72	2.72	0.46	0.80	0.41	0.33	12.77
1903	T	1.05	0.18	0.56	0.28	3.94	0.42	0.87	T	1.62	0.26	0.22	9.40
1904	T	T	0.77	0.81	2.03	2.20	1.75	0.33	2.34	0.50	0.00	0.31	11.04
1905	0.05	0.11	2.11	4.67	2.13	1.56	1.30	0.45	1.48	0.10	0.41	0.02	14.39
1906	0.23	0.10	0.92	5.59	0.59	0.54	2.05	1.21	1.64	1.57	0.22	T	14.66
Normal	0.34	0.35	0.75	1.73	1.95	1.39	2.76	1.27	0.85	0.89	0.35	0.52	13.15
Agril. Mean	0.25	.16	.56	0.66	1.90	0.77	1.77	.90	0.64	0.72	0.21	0.48	9.02
Max.	1.50	1.05	2.11	7.15	4.25	3.94	10.26	3.20	2.34	2.64	2.40	1.77	.....
Min.	T	O	0.07	0.18	0.28	0.23	0.42	0.25	O	O	O	O	.....

Established by Agricultural Experiment Station. Observers—F. L. Watrous, 1889—August, 1892; F. A. Huntley, August, 1892—September, 1895; P. K. Blinn, September, 1895—September, 1897; W. F. Crowley, September, 1897—March, 1898; H. H. Griffin, March, 1898—June, 1903; P. K. Blinn, June, 1903.

PRECIPITATION AT CHEYENNE WELLS, CHEYENNE COUNTY, COLORADO

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	.....	.....	1.00	2.00	3.10	2.32	4.97	2.35	1.92	T	T	2.25	.....
1892	0.10	0.60	2.25	0.50	.....	3.63	2.09	4.40	T	0.45	0.20	0.96	.....
1893	0.05	T	T	.....	1.10	1.15	2.50	1.64	0.68	T	0.30	0.03	.....
1894	T	1.30	0.10	0.62	2.36	0.48	1.99	1.03	0.14	0.14	T	0.55	8.41
1895	0.67	0.27	0.16	1.67	1.49	3.00	6.38	1.22	T	0.21	0.30	0.42	15.79
1896	0.45	T	0.71	3.41	2.28	3.03	2.27	3.07	0.84	0.78	T	0.60	17.44
1897	0.26	0.10	1.58	1.20	1.44	2.22	4.19	3.24	0.92	2.73	0.10	0.20	18.18
1898	0.03	0.00	0.61	1.10	5.56	3.95	2.09	1.33	2.00	0.48	0.50	0.48	18.13
1899	0.47	0.36	0.39	0.03	2.88	1.89	3.67	0.55	.78	T	2.49	0.55	14.06
1900	0.03	0.67	0.56	9.95	0.80	2.47	2.02	0.30	1.31	0.22	T	0.18	18.51
1901	0.15	0.38	0.71	4.02	1.18	0.90	2.63	2.59	1.12	0.49	0.02	0.25	14.44
1902	T	0.25	1.92	0.78	3.12	2.53	1.42	6.06	0.20	1.32	O	0.75	18.35
1903	0.34	0.79	0.23	0.94	3.71	2.63	1.87	1.89	T	T	0.75	0.13	13.28
1904	T	T	0.11	1.59	2.51	4.78	3.39	4.89	4.26	0.99	0.00	0.29	22.81
1905	0.14	0.35	2.00	5.16	2.13	2.58	2.02	1.12	2.41	0.40	0.00	T	18.31
1906	0.21	0.24	0.89	3.77	1.24	3.00	4.26	2.39	2.36	0.90	0.20	T	19.46
Means	0.19	0.35	0.83	2.45	2.33	2.54	2.98	2.38	1.18	0.57	0.30	0.48	16.58
Agril. Means	0.14	0.27	0.71	1.59	2.28	2.55½	2.29½	2.12	0.88	0.42½	0.06	0.35½	13.79
Max. for month	0.67	1.30	2.25	9.95	5.56	4.78	6.38	6.06	4.26	2.73	2.49	2.25	.....
Min. for month	T	O	T	0.03	0.80	0.48	1.42	0.30	T	T	O	T	.....

Established by the Agricultural Experiment Station. Observers—J. B. Robertson, 1891—April, 1896; J. E. Payne, April, 1896—October, 1901; L. M. Parker, October, 1901—June, 1902; J. B. Robertson, June, 1902.

MONTHLY RECORD OF PRECIPITATION, 1907

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Denver	0.46	0.33	0.54	2.91	2.93	1.15	1.52	0.23	0.74	0.17	0.40	0.45	11.83
Fort Collins	0.23	0.36	0.69	2.80	2.44	0.44	2.28	1.27	0.58	0.08	0.44	0.03	11.64
Wray	0.12	0.02	0.24	0.94	2.17	1.53	3.39	3.80	1.27	0.03	0.14	0.58	14.23
Hamps	0.15	T	0.27	2.38	1.85	0.65	2.59	1.06	0.74	0.02	0.20	0.65	10.56
Yuma	0.28	0.02	0.33	0.94	1.43	2.44	3.44	2.58	1.44	0.04	0.24	0.35	13.53
LeRoy	0.12	0.05	0.25	0.97	2.85	2.67	2.24	4.19	1.88	T	0.66	0.69	16.57
Cheyenne Wells	T	T	0.13	0.72	1.10	2.86	1.98	0.95	1.28	0.25	0.25	0.20	9.72
Rocky Ford	T	T	0.00	1.84	1.85	0.69	4.96	0.78	0.33	0.88	2.00	0.26	13.59

Press of the Fort Collins (Colo.) Express.

Bulletin 124 July, 1907

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

COLORADO FODDERS

AN EXAMINATION INTO THEIR COMPOSITION AND COMPARATIVE VALUES

BY

W. P. HEADDEN

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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INTRODUCTORY

In the following pages, I have endeavored to state my results fully enough to enable the reader to clearly understand my interpretation and have, at the same time, given the data so fully that he may draw his own conclusions, and judge whether mine are justified or not.

In this work I have had no predecessor to follow, so far as I know. The study of the chemical composition of timothy hay presented by the Pennsylvania Experiment Station is quite different from the present work, and I have not taken up timothy hay in detail, for reasons given in the proper place. The only attempt to determine the digestibility of the different extracts of any fodder that I remember to have seen mention of, was made in France. I do not recall the fodder or fodders studied or the scope of the investigation.

I do not know that any similar attempt to study the calorific value of the various portions of the fodders and the relative amounts of heat furnished by them, their coefficients of appropriation, has been made.

I have given the analytical data as fully as possible, including the ordinary fodder analyses of both the fodders and the feces, similarly their ultimate analysis, the analysis of their ashes, and what I have, for the purpose of this bulletin, designated as their proximate analysis. By proximate analysis, I mean the division of the fodder into different portions by means of the following solvents: 80 per cent. alcohol, cold water, hot water with subsequent addition of malt extract, 1 per cent. hydric chlorid, 1 per cent. sodic hydrate and chlorin in the presence of water, with subsequent washing with water, boiling sodic hydrate, 1 per cent. solution, and sulfurous acid. The portion which resisted these successive treatments has been designated as residue or cellulose.

The heat or energy, given in small calories, removed by these successive treatments, and the percentage of this heat value appropriated by the animals have been studied in detail for three of the fodders, alfalfa, corn fodder and the saltbush, *Atriplex argentea.*

The distribution of nitrogen and also that of the furfurol, in these various extracts has been determined, but no attempt has been made to distinguish between arabinose and xylose, all being calculated as xylan. Determinations of mucic acid were made on these fodders, and the sugar obtained by treating the alfalfa hay with 1 per cent. hydric chlorid has been considered as being derived from galactan, which is also probably present, according to our results, in some of the other fodders.

The reducing power of the sodic hydrate extract has been indicated as xylan with an interrogation point, because it is very probably not derived from xylan. The quantity of this sugar is altogether insignificant, except in the case of the saltbush, in which it is relatively large.

COLORADO FODDERS

AN EXAMINATION INTO THEIR COMPOSITION AND COMPARATIVE VALUES

By W. P. HEADDEN

SEC. 1. In Bulletin No. 39 of this Station, I endeavored to study alfalfa, clover, pea-vine, and our native hay, but particularly alfalfa hay with special regard to the carbohydrates, including under this term the crude fibre and nitrogen-free extract.

§2. In Bulletin No. 93 I have given the results of experiments on the digestibility of alfalfa, timothy and native hay, also on the saltbush, *Atriplex argentea,* corn fodder and sorghum.

§3. In Bulletin 93, I followed the beaten path and gave the coefficients of digestion as obtained for the usual groups, proteids, crude fibre, nitrogen-free extract, etc. In the present bulletin, I shall take up the same hays and fodders treated of in Bulletin No. 93, but I shall consider them from the standpoint of Bulletin No. 39, following the same general method that I used in that work, but extending it very considerably.

§4. While it might be of scientific interest to study the ether extract, it is not a very important factor in the study of the coarse fodders presented in this bulletin as it, at most, amounts to only a small percentage of these fodders, usually to less than three per cent., and these three per cent. are composed of fats, waxes, coloring and other matters, none of which are involved in the questions which form the object of this study.

§5. I have discovered no good reason for taking up the extract by absolute alcohol, so I began the work by extraction with boiling 80 per cent. alcohol, which removes coloring matter, sugars and extractives. We found that extraction with four portions of alcohol, boiling each portion 20 minutes, was quite sufficient to exhaust the sample. We used 10 grams of hay and 450 c. c. of alcohol. The amount extracted by the fourth portion of alcohol amounted to only 0.30 of one per cent. of the air dried hay.

§6. We attempted to evaporate the extracts to dryness and weigh them, but in checking against the weight of the dried residue we found a difference of about two per cent., *i. e.,* the dried extracts were about this much too low. After considerable work to see if we could not obtain better agreement between the direct weighings of the extracts and the weight of the remaining hay, we decided to take the loss of weight as indicated by the residual hay as the weight of the material extracted. Had we been trying to obtain results to be expressed in terms of the extract, this method would of course, not be admissable, but as we have expressed all results in terms of

the air dried hay or fodder, this method has the patent advantage of giving every percentage upon a basis which can be easily duplicated within quite narrow limits which we found would be attended with considerable difficulty if we used the weight of the extracts obtained, as each one showed a deficit for which we could not account. The weight of the residual portion of the hay seemed, furthermore, to be less subject to change, debarring the absorption of moisture which is comparatively easily guarded against, than that of the extract.

§7. As already stated, the boiling, 80 per cent. alcohol extracted the hays readily and even the first portion removed practically all of the coloring matters which, particularly in the case of alfalfa, was large and difficult to remove from the extract.

§8. It was not possible for us to prosecute any examination of these coloring matters, but it was necessary that we should remove them completely from the solution before we could proceed to test for sugars. The matter of decolorizing these solutions proved to be a difficult one. I first tried the effect of adding potassic aluminate and the precipitation of the aluminic hydrate by passing carbon-dioxid through the solution. My idea was that the precipitating aluminic hydrate might carry down all of the coloring matter, this, however, did not prove to be the case and the filtrate from the $Al_2 (O H)_6$ had a bright yellow-red color. We pursued this a little further but the results, while interesting in themselves, did not advance the work in hand.

§9. Though I desired to avoid the use of basic acetate of lead, it proved to be the most effective agent in removing the yellow coloring matter, the filtrate however, was green and worked badly with the Fehling's solution, yielding a flocculent precipitate which may have contained cuprous oxid, it probably did, but the precipitate was essentially something else. We found that the addition of cupric sulfate removed the green coloring matter completely, yielding a colorless solution, provided no excess of the cupric sulfate had been added. The use of the basic acetate of lead and cupric sulfate worked well.

In Bulletin 39, I recorded the observation that the reducing power of such extracts are greatly diminished by the addition of basic acetate of lead but that I failed to detect any sugar in the precipitate.

§10. In the present work, it was imperative to establish one fact, *i. e.*, that the combined use of the lead and copper salts did not in any way affect the quantity of sugar, sucrose, present either by removing it with the precipitate or causing its inversion.

§11. In order to establish this point, several portions of the extract which had been made up to a given volume, after the alco-

hol had been distilled off, were taken and a weighed portion of pure sugar added to some of them. All the portions were then decolorized by the use of lead acetate, sodic sulfate and cupric sulfate, always added in this order, the precipitate filtered off and washed, the excess of copper removed by H_2S and the H_2S expelled by passing $C O_2$ through the solution, the two last operations were quite unnecessary, but I thought that it could happen that I might wish to remove the copper and subsequently the $H_2 S$ in this manner and so I included them in this test. The results showed that the sugar was wholly unchanged both in character and quantity by these operations. This method was therefore adopted, as the substances which exert a reducing action upon the Fehling solution and are removed by these precipitants are neither glucose nor saccharose, the presence and quantity of which I wished to establish. The other substances are of course included in the extract yielded by the hay.

§12. The total reducing power of the cold water extract after inversion by heating with hydric chlorid is attributed to the presence of gums. It is probable that this class of bodies is the source of the reducing sugars produced, but the amount of sugar or gum present in this extract is so small that it is no matter of great moment by what name we designate it.

§13. The reducing power of the hot water extract after the action of malt extract has been expressed as starch. The total amount extracted by the cold and hot water respectively is much less than one would expect, but it must be borne in mind that the hay or fodder had been previously extracted, we may say exhausted, with boiling 80 per cent. alcohol. The amounts extracted by these media are also much more nearly equal than one would expect, the cold water in a few instances actually dissolving more than the hot water and malt extract.

§14. The hydric chlorid used was a one per cent solution. The extraction of the hay or fodder with this reagent gave us more trouble than all other determinations combined. All of the work recorded in this bulletin was done in duplicate and if our results did not agree, the work was repeated until we found how to proceed in order to obtain concordant results.

§15. It is true that agreement of results may not be conclusive proof that the method used is the best one, or even that the work has been correctly done, but their disagreement, when obtained by the same method and under similar conditions, is conclusive of one of two things, either that the operations have been interrupted at different stages or that the method is wholly inadequate and an end point is not attainable. We found that the different hays and fodders resisted the action of this one per cent.

solution of hydric chlorid in very different degrees. In those cases in which the amount of xylan was high, we found that boiling for thirty minutes did not suffice for the accomplishment of our purpose, *i. e.*, to carry the action of the hydric chlorid to an end.

§16. In some fodders and dungs we found it necessary to boil them two, and in a few cases, even three times with separate portions of the acid in order to obtain results which agreed reasonably well. We found, too, that the inversion of this extract was much more difficult than of any of the others,—it being necessary to use ten c. c. conc. hydric chlorid and to digest in the water bath for two hours; this means at our altitude, a temperature of about 85° to possibly 90° C. in the solution, even though the water in the bath is kept boiling briskly. We found that this quantity of acid and time gave us the highest results, measured in terms of the reducing power, and usually a good agreement between the duplicates.

§17. The sodic hydrate used was also a one per cent. solution. The reducing power of this extract, after inversion, was, as a rule, very small. We observed in this connection that the reducing power of this extract was frequently higher in those cases in which we found it difficult to complete the extraction with hydrochloric acid than in others. I interpret this variation as suggesting that the small amount of reducing sugars found in the sodic hydrate extract may belong to the hydric chlorid extract rather than indicate the presence of a hexose sugar.

§18. The residue left after treatment with sodic hydrate was washed free from Na O H, dried, etc. It was next moistened with water and spread out on the inner surface of a small flask which was connected with a chlorin apparatus and allowed to stand for an hour after the flask had become entirely filled with the gas. It was then washed, boiled with dilute Na O H and subsequently with H_2 S O_3 and the residue finally dried and weighed as cellulose. The action of chlorin, etc., did not produce any reducing sugars, at least there were none present in the filtrate.

§19. In Bulletin 93, we have recorded our results in determining the coefficients of digestion of the groups, substances usually taken cognizance of in our ordinary fodder analyses, *i. e.*, Dry Matter, Ash, Fat, Protein and Nitrogen-free Extract; in the present bulletin, I intend to present the results of these same experiments using a different series of groups, or to give the coefficients of digestion for the alcoholic extract, cold water extract, hot water extract, one per cent. hydic chlorid extract, one per cent. sodic hydrate extract, chlorin extract, and lastly, of the cellulose or that portion which persistently resists the action of these reagents. In addition to the preceding coefficients, I shall give the coefficients of digestion

of those groups which yield the reducing sugars under the conditions already indicated and also of those complexes which yield furfurol on distillation with twelve per cent. hydric chlorid solution, but as I have sought to determine the distribution of these groups and complexes in the different extracts it will be quite impossible to bring the results within the compass of a single table. I will, therefore, be compelled to make two statements of the results which will supplement each other, but which cannot in any sense replace or contradict each other. I will also give the calorific values of the hays, dungs and of the residues yielded by the respective treatments in the case of the alfalfa, corn fodder and saltbush, these being the best for our purposes; timothy hay, sorghum and native hay not suiting so well. Our native hay is a mixture of such character that results obtained with it would be of little value except in a very general sense.

§20. The hays and fodders used in this work are the same as those used in Bulletin 93, in fact, that work was done largely for the purpose of obtaining data according to the conventional methods for the particular samples used n this study. The hays and fodders were intentionally chosen to represent both legumes and grasses grown and preserved under our Colorado conditions.

§21. The distribution of the nitrogen in these extracts appears from the results of the work recorded in Bulletin 39, to present some points of more than usual interest. For instance, we found that 27 per cent. of the total nitrogen in alfalfa hay was removed by extraction with boiling 80 per cent. alcohol and subsequent treatment with cold water. This nitrogen may have been contained in the coloring matters to a greater extent than in some other hays, but it is certainly not all contained in the chlorophyll and it is not probable that it is amid nitrogen for it exceeded the amount that we had previously found in alfalfa hay in this form. The advisability of making these nitrogen determinations is further indicated by the persistence with which some nitrogen remains with the crude fibre after boiling with 1.25 per cent. sodic hydrate solution. In the work referred to we found that 4.51 per cent. of the total nitrogen in alfalfa hay remained in the crude fibre, when it had been prepared in the usual way by boiling for thirty minutes with the 1.25 per cent. sodic hydrate solution. We shall see that this was not a chance result, but indicated a general fact and we shall further see that this statement is correct for the hays and fodders studied in this bulletin.

§22. The distribution of the ash in these various extracts has been wholly disregarded.

§23. The analysis of the dungs present, of course, the same questions that the conventional methods do in regard to the com-

pounds in which the nitrogen is contained, *i. e.*, whether it is contained in undigested portions of fodder or in fecal matter. The results obtained in this work in regard to the nitrogen, are open to the same questions that those of our ordinary analysis and possibly to even more serious ones, for we divide it up into six or seven portions instead of presenting it as the common constituent of a single class without raising any further questions.

§24. The samples of hays fed were of course the same throughout the experiments, so that one analysis represents the whole of any fodder fed and no questions can arise relative to this; concerning the orts and dungs, however, there might be a question. In Bulletin 93, we calculated the coefficient of digestion for each individual animal and took the average of the coefficients so found as the coefficients of digestion of the several hays and fodders. Owing to the tediousness of the work, we followed a different procedure in this case, *i. e.*, we made composite samples of the dungs, by taking the same aliquot part of the dung voided by the different sheep in each 24 hours during the time of the experiment and combining them into a composite sample. The sample of orts was prepared in a similar manner.

ANALYTICAL DATA—ALFALFA HAY.

§25. The following analyses have been brought together in order to present, succinctly as possible, all that our analyses tell us about the fodders and their digestibility.

The average coefficients of digestibility found for this particular alfalfa hay were for the dry matter 62.08, ash 57.67, fat 29.86, protein 72.54, fibre 49.93, and for the nitrogen-free extract 72.89. The general facts presented by the data concerning alfalfa pertain to all of the other fodders.

TABLE I.

ALFALFA HAY.

FODDER ANALYSIS.

ALFALFA HAY		FECES OF SHEEP NO. 6	
Moisture	7.75	Moisture	6.82
Ash	11.77	Ash	12.15
Ether Extract	1.62	Ether extract	3.12
Proteids	15.03	Proteids	10.86
Crude Fibre	30.28	Crude Fibre	40.34
Nitrogen-free extract	33.55	Nitrogen-free extract	26.83
	100.00		100.00

TABLE II.

ASH ANALYSIS.

ALFALFA		CORRESPONDING FECES*	
Percentage of ash in hay..	11.77	Percentage of ash in Feces..	13.15
Sand	8.524	Sand	12.682
Silicic acid	6.844	Silicic acid	8.676
Sulfuric acid	6.269	Sulfuric acid	2.037
Phosphoric acid	3.158	Phosphoric acid	7.629
Carbonic acid	17.399	Carbonic acid	21.081
Chlorin	6.801	Chlorin	0.666
Potassic oxid	27.271	Potassic oxid	3.207
Sodic oxid	4.287	Sodic oxid	1.733
Calcic oxid	14.736	Calcic oxid	29.590
Magnesic oxid	4.006	Magnesic oxid	7.719
Ferric oxid	1.428	Ferric oxid	1.440
Aluminic oxid	0.288	Aluminic oxid	0.879
Manganic oxid (br)	0.180	Manganic oxid (br)	0.330
Ignition	0.341	Ignition	2.481
	101.532		100.150
Oxygen, Equiv. to chlorin..	1.532	Oxygen Equiv. to Chlorin..	.150
	100.000		100.000

TABLE III.

ULTIMATE ANALYSIS.

ALFALFA HAY		CORRESPONDING FECES	
Carbon	43.517	Carbon	45.769
Hydrogen	5.868	Hydrogen	5.494
Nitrogen	2.405	Nitrogen	1.738
Sulfur	0.342	Sulfur	0.189
Chlorin	0.819	Chlorin	0.123
Phosphorus	0.162	Phosphorus	0.405
Potassium	2.665	Potassium	0.323
Sodium	0.374	Sodium	0.156
Calcium	1.239	Calcium	2.569
Magnesium	0.286	Magnesium	0.566
Oxygen plus the remaining ash constituents	42.323	Oxygen plus the remaining ash constituents	42.668
	100.000		100.000

§26. For good, clean, alfalfa hay the ratio of thoroughly air-dried feces to the hay consumed is one to two and seven-tenths or five and one-half pounds of hay eaten will correspond to just a trifle more than two pounds of feces.

§27. The silicic acid has not been taken into account in the preceding analyses because it is very uncertain how much of it is due to fluxing of the minerals constituting the dust and sand found in the ash.

§28. These data show the extent to which the potash is taken up by the animal system, the feces being very poor in this substance

*Sheep No. 6.

while the opposite is the case with the phosphoric acid and lime.

§29. The ultimate composition of the hay and feces does not appear to differ as much as one might expect, so far as the carbon, hydrogen and oxygen are concerned but an ultimate analysis of a mixture of such complex substances as we have to do with in these cases could scarcely be expected to show decided differences, still it shows that 61.6 per cent. of the carbon in the hay consumed, is digested. The feces show a higher percentage of carbon than the hay, which may indicate that the compounds having the higher carbon content are less readily attacked than those with less. These analyses further show that the hydrogen, nitrogen, sulfur, chlorin and the alkalies, particularly potassium, are very largely taken up from the fodder, while the calcium, magnesium and prosphorus are voided with the feces to a very large extent. This is strikingly the case in regard to phosphorus, for according to the ratio given for the hay consumed to the feces voided, 5½ : 2, it results that of 892 parts of phosphorus ingested by sheep, 810 parts are voided with the feces, which indicates a coefficient of digestion of 10.3 per cent. for the phosphorus consumed, which is quite small, averaging 1.31 grams per day, of which only 10.3 per cent. or 0.131 gram was appropriated by the animal. The potassium stands in strong contrast to this with a coefficient of 95.6 per cent. The following pages present some further considerations, based on different data.

§30. The following analyses are of an entirely different character and present a study of the same hay from another standpoint.

§31. The statement of the analyses is given so fully that no further explanation is needed in this place.

TABLE IV.

ANALYSIS OF ALFALFA HAY.

The percentages given in following analyses are computed on air-dried hay.

	I	II	Av.
	Per cent.	Per cent.	Per cent.
Eighty per cent. alcohol extracted...	27.177	27.818	27.50
Cold water, 24 hours digestion, extracted	8.535	8.785	8.66
Hot water and malt extracted... ...	4.790	3.950	4.37
Hydric chlorid, 1 per cent. sol., extracted	12.487	11.968	12.23
Sodic hydrate, 1 per cent. sol., extracted	15.341	17.046	16.19
Chlorin, etc., extracted.....	8.372	9.155	8.76
Cellulose, residue	23.298	21.278	22.29
			100.00

SUGARS IN THE EXTRACTS.

Glucose in the alcoholic extract.....	1.280	1.280	1.28
Sucrose in the alcoholic extract.....	0.942	0.942	0.94
Gums, etc., in cold water extract.....	0.833	0.770	0.80
Starch in hot water and malt extract	1.267	1.260	1.26
Galactan, inverted by 1 per cent. HCl	2.960	2.770	2.87
Reducing power of the 1 per cent. Na O H extract	0.320	0.378	0.35

The average of two determinations of galactan made according to the official method was 2.89 per cent. It seems probable that the reducing power of the one per cent. HCl extract of alfalfa hay is wholly due to galactan, but only partly so in corn fodder and in native hay.

TABLE V.

ANALYSIS OF ALFALFA ORTS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	26.532	26.276	26.40
Cold water, 24 hrs. extracted.....	8.580	8.559	8.57
Hot water and malt extracted.....	3.970	4.256	4.11
Hydric chlorid, 1 per cent. sol. extracted	11.687	11.863	11.78
Sodic hydrate, 1 per cent. sol. extracted	16.637	14.885	15.76
Treatment with chlorin, etc., extracted	8.519	9.853	9.19
Cellulose remaining	24.074	24.308	24.19
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	1.25	1.25	1.25
Sucrose in alcoholic extract.....	1.67	1.45	1.56
Gums in cold water extract.....	0.47	0.38	0.43
Starch in hot water extract.....	0.94	0.97	0.96
Galactan	3.96	4.45	4.21
Reducing power of sodic hydrate extract	0.70	0.97	0.80

TABLE VI.

ANALYSIS OF DUNG OF SHEEP FED ON ALFALFA HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted...	19.107	19.363	19.24
Cold water, 24 hrs. digestion, extracted	4.912	4.872	4.89
Hot water and malt extracted.....	3.635	3.349	3.49
Hydric chlorid, 1 per cent. sol., extracted	13.580	12.457	13.02
Sodic hydrate, 1 per cent. sol., extracted	12.796	15.166	13.98
Treatment with chlorin, etc., extracted	19.711	15.091	17.40
Cellulose remaining.....	26.259	29.702	27.98
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.40	0.52	0.46
Starch in hot water and malt extract	0.21	0.21	0.21
Galactan in hydric chlorid extract..	1.37	0.98	1.18
Reducing power of sodic hydrate extract	1.57	1.30	1.44

TABLE VII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	3671.4	260.5	3410.9	890.9	2520.0	73.88
Total cold water extract....	1157.2	84.6	1072.6	228.4	846.2	78.89
Total hot water malt extract	583.6	40.6	543.0	161.6	381.4	70.24
Total hydochloric acid ext..	1630.9	116.2	1514.7	602.9	911.8	60.20
Total sodic hydrate extract	2161.6	155.5	2006.1	647.3	1358.8	67.72
Total chlorin etc., extract..	1170.6	90.7	1079.9	805.7	274.2	25.39
Total cellulose	2976.1	238.7	2737.4	1295.6	1441.8	52.67
Total dry mater	13351.4	986.8	12364.6	4630.4	7734.2	62.55

§32. The average coefficient of digestion of the dry matter in this hay obtained by the usual method was found to be 62.05. It is given as 63.95 on page 23 of Bulletin 93, but this is a mistake It should be 62.05.

TABLE VIII.

COEFFICIENTS OF DIGESTION OF THE CARBOHYDRATES IN ALFALFA HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
In alcoholic extract, glucose	170.9	12.3	158.6	00.0	158.6	100.00
In alcoholic extract, sucrose	125.5	15.4	110.1	00.0	110.1	100.00
In cold water ext., gums, etc.	106.8	4.2	102.6	19.4	83.2	81.09
In hot water malt ext. starch	164.2	9.5	154.7	9.7	145.0	93.73
In 1 p. c. hydrochloric acid extract, Galactan	381.9	41.5	340.4	54.6	285.8	83.96
In 1 p. c. sodic hydrate extract, (Hexose?).....	46.7	7.9	38.8	66.7	Excess —27.9	
In chlorin, etc., extract, this extract showed no reducing power.						
Cellulose residue after chlorin, etc., treatment						52.67

§33. In the preceding table, it will be noticed that the amount of reducing sugar found in the one per cent. sodic hydrate extract for the dung exceeds the amount found for the extract of the hay by a very considerable amount, 71.91 per cent.

§34. At first, I thought that the small amount of reducing sugar found in the solution obtained by boiling the hays or fodders with the one per cent. solution of sodium hydrate, was due to imperfect extraction by the hydrochloric acid or perhaps owed its origin to complexes which had been attacked by the hydrochloric acid and thereby rendered soluble in the sodic hydrate, but the relatively large amount extracted from the dung by this reagent, for we find the same excessive amount in the dungs corresponding to each of the six fodders suggests that it is not an accident due to the incompleteness of the action of the hydrochloric acid but that it is due rather to the presence of some compound which effectively resists the action of the hydrochloric acid but which is soluble in sodic hydrate and is either hydrolized by this agent or is made susceptible to the action of the hydrochloric acid subsequently used as the hydrolytic agent. If this were the indication of even a duplicate analysis of the dung corresponding to one of the fodders, one would certainly be justified in doubting its sufficiency as the basis of any inference, but it is not simply an accidental agreement of duplicate results, obtained in the analysis of a single sample of dung, but is the result of duplicates made on the dungs corresponding to six fodders which differ materially from one another. This difference between the fodders and the corresponding dungs may be due to changes produced in the fodders during their passage through the alimentary tract or to excrementitious matter proper. It seems probable that it is the latter.

§35. In regard to the reducing sugar produced by the action of the dilute hydric chlorid, I have in the case of the alfalfa attributed it to the presence of galactan because the agreement between the determination of mucic acid and the reducing power of the inverted solution was good; in the other cases I have used the term xylan as a general term for the pentosans hydrolized by the dilute hydic chlorid. Mucic acid determinations made on the samples of corn fodder and native hay indicate the presence of some galactan but its quantity is much less than the total reducing power, so it is probable that both galactan and xylan are present, but I have used the term xylan in all cases except in that of alfalfa.

§36. The total reducing power of the extract yielded to one per cent. sodic hydrate solution by alfalfa hay corresponds to 38.8 grams, whereas the reducing power of the extract yielded by the feces under the same treatment corresponds to 66.7 grams or 1.7 times as much. Whatever the source of this reducing power may be it is evidently much more abundant in the extract of the dung voided than in the hay consumed. It is probable that the excessive reducing power of the sodic hydrate extract of the dung over that of the hay is due to its action on fecal matter and not on the undigested rem-

nants of the hay. This excessive reducng power of the sodic hydrate extract of fhe dung over that of the hay is not an accident or attributable to inaccurate work, for it is uniformly the case with all of the dungs corresponding to the six fodders used.

§37. This result is similar to that obtained for the coefficient of digestion for the ether extract in the first series of experiments made on the digestion of alfalfa hay in which the amount of ether extract obtained from the feces was more than double the amount consumed. In this case, I attributed this excess to the solubility of fecal matter only after I had canvassed every other apparent explanation, because it was observed in one series of experiments only and was not observed in the case of any other fodder than the alfalfa. If other experimenters have met with such striking results, they have rejected them, as I was tempted to do, for the simple reason that others have done this work in the same way and the recorded results agreed in showing that my results were, to say the least, very exceptional. In this case, however, I have a series of six very different fodders and they agree in showing that, in this respect, there is a marked difference between the fodders and the feces of the animals feeding on them.

PENTOSANS.

§38. There are certain complexes existing in the fodders which when subjected to distillation with hydrochloric acid yield furfurol. In this work, I have considered this furfurol as such and have endeavored to determine its coefficients of digestibility for the various extracts.

§39. In Bulletin 39, we found the total amount of furfurol calculated as xylan yielded by alfalfa, to range for the first cutting from 9.44 to 14.42 per cent.; for the second cutting, hay grown at Rocky Ford, 12.34 per cent. The average found for the cutting of 1894 was 11.44 per cent.; for 1896, 11.48 and the average for all of the determinations made on samples covering the two years was 11.48 per cent.

§40. The furfurol found in the hay used in these experiments, was 8.16 or 13.38 xylan; in the orts 9.95 per cent.; in the feces 12.69 per cent. xylan. There were fed 1786.4 grams of xylan. The orts contained 98.19 grams and the feces 587.6; accordingly 1100.6 grams of xylan had been digested or the coefficient of digestion for the total xylan was 65.12. The corresponding amounts of furfurol are, in the hay fed 1089.5 grams, in the orts 59.9 grams, in the feces 318.9 grams, digestion coefficient 65.18.

§41. We determined the furfurol in the residue after the extraction and not in the evaporated extract for the same reason that we determined the extracts themselves by difference, *i. e.*, be-

cause we found a deficiency of about two per cent. on evaporating the extracts to dryness.

TABLE IX.

FURFUROL FOUND IN ALFALFA HAY, ORTS AND THE FECES AND IN THE RESIDUE AFTER TREATMENT WITH THE VARIOUS SOLVENTS.

	Alfalfa hay Per cent.	Alfalfa orts Per cent.	Feces Per cent.
Original Hay	8.160	6.068	7.742
Residue after 80 per cent. alcohol	7.078	5.367	7.638
Residue after cold water	6.494	5.322	Same
Residue after hot water	5.736	5.122	6.940
Residue after 1% hydric chlorid	4.220	3.765	Same
Residue after 1 per cent. sodic hydrate	2.586	2.131	3.778
Residue after chlorin, etc.	1.919	2.080	1.394

TABLE X.

THE COEFFICIENTS OF DIGESTION FOR FURFUROL IN THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Furfurol in alcoholic extract	144.50	6.90	137.60	4.80	132.80	96.51
Furfurol in cold water ext	77.98	0.40	77.58	0.00	77.58	100.00
Furfurol in hot water ext...	101.20	2.00	99.20	32.30	66.90	67.44
Furfurol in hydrochloric acid extract	202.40	13.40	189.00	0.00	189.00	100.00
Furfurol in sodic hydrate ext	218.20	16.10	202.10	146.90	55.20	27 81
Furfurol in chlorin, etc., ext	89.05	10.50	88.55	110.39	—21.84	....
Furfurol in residue, cellulose	256.20	20.50	235.70	64.54	171.16	72.62
	1089.53	59.80	1029.73	358.90	670.83	65.15

§42. The treatment with boiling one per cent. hydric chlorid aims at the removal of easily hydrolized substances which might yield fufurol on distillation with the stronger, 12 per cent., acid. This treatment removes considerable quantities of furfurol yielding substances from the hay which apears to be wholly digestible for we find none in the feces. On the other hand, the hydric chlorid, one per cent. solution, removes hydrolyzable substances from the feces corresponding to 1.03 per cent. of galactan. The one per cent. hydric chlorid solution removes from the hay 1.52 per cent. of furfurol and contains reducing sugars equal to 3.01 per cent. of galactan which is probably the source of the reducing sugar, as the hay yields when treated with hydric nitrate, sp. gr. 1.15, according to the official method, mucic acid corresponding to 2.86 per cent, galactan, so it seems probable that both pentose and hexose sugars are represented in the composition of the hay.

§43. I have elsewhere noted the fact that in making duplicate determinations of this reducing power, it was difficult to obtain agreement in the results and that in some fodders, we had to repeat the treatment as many as three times to get even a fair agreement. I interpret this as indicating a radical difference in the character of the compounds in the different fodders which are attacked by this reagent.

METHOXYL GROUP.

§44. At the time this work was done no tests, so far as I knew, had been made to prove whether this group existed in ordinary plants. Recently, however, it has been shown that certain woods, not known to contain quinine or related alkaloids, yield methyl iodid on distillation with strong hydriodic acid showing the presence of compounds containing the methoxyl group.

§45. The presence of aromatic compounds in the urine of herbivores and the fact of the general prevalence of alkaloidal compounds in plants, some of which contain the methoxyl group, suggested the probability of the presence of this group in the fodders. I accordingly attempted its determination, using the original Zeisel method.

§46. I did not determine this group in the orts, for both the amount of the orts and the percentage of this group present being small, no great error is introduced by the omission, besides my chief object was to establish the presence or absence of the group in the case of each fodder and obtain, if possible, an idea of the amount of these compounds appropriated by the animal, an approximate coefficient of digestion. I did not hope to accomplish more than this.

§47. The duplicate, and in some cases, triplicate determinations, agreed fairly well. The largest difference in twelve sets of duplicates, including also some triplicates, was less than one-half of one per cent. We checked our work using quinine, a commercial article, obtaining a fair agreement in our determination, but the results were a little lower than required by theory, which leads me to infer that my results are too low rather than too high.

METHOXYL GROUP IN ALFALFA HAY FED AND FECES VOIDED.

	I Per cent.	II Per cent.	Av. Per cent.
Alfalfa Hay	1.18	1.23	1.21
Dung, sheep fed alfalfa.....	2.46	2.31	2.39

§48. The hay consumed was 12,364.8 grams containing 148.38 grams of the methoxyl group; the feces weighed 4,630.5 grams and contained 110.7 grams of methoxyl, giving us a digestion coefficient of 25.42 for this group.

§49. I will anticipate a general result which will be evident when the determinations of this group in all the samples have been given, *i. e.,* that it is present in hays made from grasses and leguminous plants, also in corn fodder, sorghum and the saltbush, *Atriplex argentea,* being most abundant in the last named plant; further that the percentage of this group present in the dung is approximately twice that in the hay or fodder, except in the case of the saltbush in which it is only one and one-half times as much as in the saltbush itself.

AMID NITROGEN IN ALFALFA HAY.

§50. In calculating the proteids we have multiplied the total nitrogen by 6.25 consequently our product is too high, as more or less of the nitrogen is present in the form of amids, compounds containing a higher percentage of nitrogen and, consequently, having a factor less than 6.25, if for example, the nitrogen were present as asparagine, its factor would be 4.7.

§51. In the following statement I have given the proteid equivalent to the amids. I have made no attempt to divide the nitrogen compounds further than into the two groups, proteids and amids.

§52. The amid nitrogen found in samples of alfalfa hay cut at half bloom is as follows, 0.372, 0.350, 0.614; average is 0.444 which is rather far removed from the maximum which is, however, the highest found in eleven samples. The amid nitrogen found in the alfalfa hay used in this series of experiments was 0.446 agreeing very well with the average found for the other samples cut in half bloom.

§53. The proteids in the alfalfa hay fed, corresponding to the amid nitrogen, amounted to 372.11 grams; in the orts 34.66 grams; consumed 337.45 grams; voided 62.23 grams; digested 275.22 grams, from which we obtain 81.55 for the coefficient of digestion for the amid nitrogen.

THE PROTEIDS REMOVED BY THE VARIOUS SOLVENTS AND THEIR COEFFICIENT OF DIGESTION.

§54. As the boiling 80 per cent alcohol removed practically all the coloring matters from the hays, I deemed it advisable to extract them with anhydrous ether and determine the nitrogen removed in this manner. I have assumed that the nitrogen thus removed is principally contained in the coloring matters. For this extraction, I use 30 grams of air-dried hay, macerated it with 150 c. c. of ether for 16 hours, and then subjected it to extraction in a soxhlet extractor for ten hours. Our air-dried hay carries from 5 to 7 per cent. of moisture. I have repeatedly compared the results

obtained by extracting air-dried hay with those obtained from the same hay dried in the water oven, also in hydrogen and have seldom found so large a variation that it was of any practical significance. The maximum amount of nitrogen found in the ether extracts of the three hays, alfalfa, timothy and native hay, was contained in the extract from the native hay which contained 0.007 per cent.; that from the timothy contained nitrogen equal to 0.0033 per cent. and that from the alfalfa 0.0032 per cent., calculated on the air-dried hay. The largest one of which corresponds to less than 0.05 per cent. of proteids.

§55. The weight of the dried ether extracts from these three hays varied from 0.5 to 0.75 grams from which it is evident that the coloring matters in these hays must be poor in nitrogen.

§56. If we assume that the nitrogen in these ether extracts is present as proteid nitrogen there would be in that from the native hay approximately 0.05 per cent., a quantity which we can disregard in ordinary work but this is twice as large as the amount found in either of the other two hays.

§57. In regard to the sulfur in alfalfa, the question has frequently suggested itself whether it belonged mostly to the proteids or whether it was present in combination, as sulfuric oxid, probably forming calcic sulfate. Wishing to answer this question in connection with the proteids, we digested a quantity of hay with dilute hydrochloric acid and washed it thoroughly. The sulfuric acid was then precipitated as baric sulfate and weighed after purification. The sulfur present in the hay as sulfuric acid amounted to 0.68 per cent. The total sulfuric acid estimated from that found in the ash, allowing a loss of two per cent. in incineration, was 0.94, leaving sulfur equivalent to 0.26 per cent. of sulfuric acid as proteid sulfur.

§58. Corn fodder treated in the same manner did not show the presence of any sulfuric acid and the sulfur is probably present as proteid sulfur and not in the form of sulfates.

§59. In the following statements, the proteids, respectively the nitrogen calculated as proteids, soluble in 80 per cent. alcohol included the nitrogen soluble in the ether which, as we have just seen, is a very small amount, not more than 0.05 per cent.

§60. The coefficients of digestion for the proteids contained in the various extracts of alfalfa hay:—

TABLE XI.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS DISSOLVED OUT OF ALFALFA HAY BY THE VARIOUS SOLVENTS.*

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in boiling 80 per cent. alcohol.....	640.88	46.47	594.41	108.82	485.59	81.69
Proteids soluble in cold water	90.79	26.05	64.74	42.60	22.14	34.20
Proteids soluble in hot water and malt	134.85	9.87	124.98	68.53	56.45	45.17
Proteids soluble in 1 per ct. hydric chlorid	126.84	1.18	125.66	50.47	75.19	59.84
Proteids soluble in 1 per ct. sodic hydrate	937.28	75.58	851.70	154.20	697.50	81.89
Proteids soluble in chlorin, sodic hydrate and sulfurous acid	45.40	5.92	39.48	50.01	(—10.53)	———
Proteids remaining in the cellulose	17.36	1.28	16.08	13.43	2.65	16.48
			1817.05	488.06	1328.99	72.92

§61. The coefficients of digestion found for the proteids by the usual method, and given on page 23, Bulletin 93, are for sheep No. 4, 73.68 per cent.; sheep No. 5, 73.58 per cent.; sheep No. 6, 70.36 per cent.; the average is 72.54 per cent. The coefficient found by calculating it from the sum of the respective extracts of the hay, and dung is 72.92 per cent. actually in better agreement with the two higher coefficients found for sheep No. 4 and 5, than the result obtained for sheep No. 6.

§62. This coefficient, 72.92, would be slightly changed if we made a correction for the amid nitrogen found, but this is nearly correct for the total nitrogen. This statement applies to all the coefficients for the proteids.

THE CALORIFIC VALUE OF ALFALFA HAY.

§63. The calorific value of the hay was determined by means of the bomb calorimeter. By hay, we mean the air-dried hay as fed to the sheep; it contained 7.75 per cent. moisture and 11.77 per cent. ash. Its calorific value was 4,050 calories,† and that of the dung was 4,300 calories. The total hay consumed by the three sheep was 12,364.8 grams. The air-dried feces weighed 4,630.5 grams, which shows that the animals used 62.30 per cent. of the total heat value of the hay. I have assumed that the orts did not

*I have used the term proteids in this place to signify the product of the nitrogen multiplied by 6.25. This remark applies to all of the fodders. Everyone knows that this is conventional and does not mean that there is only one class of nitrogenous compounds present.

†The Calorie used throughout this Bulletin is the small calorie.

differ from the hay because I was compelled to, due to the fact that the orts had all been used for other determinations. The total amount of the orts was small.

§64. The total heat consumed as dry matter by the three sheep was 49,585,495 calories; the total heat value of the dry matter contained in the feces was 18,629,832 calories; there were accordingly 30,955,663 calories appropriated by the sheep, equivalent to 62.43 per cent. of the energy value of the hay. By appropriated I mean that the energy was taken up and either stored in the body or eliminated in some other way than through the alimentary tract as undigested food. The energy escaping in the exhalations, as well as that contained in the urine, is included in the term appropriated.

TABLE XII.

The dry hay gave the following extracts and residue:

	Per cent.
Soluble in boiling 80 per cent. alcohol	21.40
Soluble in cold water	9.38
Soluble in hot water and malt	4.73
Soluble in boiling 1 per cent. hydric chlorid	13.35
Soluble in boiling 1 per cent. sodic hydrate	17.54
Soluble in chlorin, etc.	9.45
Residue—cellulose—	24.15
	100.00

The distribution of the ash in these extracts was not determined.

TABLE XIII.

THE CALORIFIC VALUE OF THE HAY AND OF THE SEVERAL RESIDUES.

The calorific value of the dry hay	4363 calories
The calorific value of residue after extraction with 80 per cent. alcohol	4270 calories
The calorific value of residue after extraction with cold and hot water	4517 calories
The calorific value of residue after extraction with 1 per cent. hydric chlorid	4759 calories
The calorific value of residue after extraction with 1 per cent. sodic hydrate	4603 calories
The calorific value of residue after extraction with chlorin, etc.,	4210 calories

TABLE XIV.

Calories removed from alfalfa hay by the successive treatments.

One gram of hay yields to boiling 80 per cent. alcohol	1007 calories
One gram of hay yields to cold and hot water with malt	443 calories
One gram of hay yields to boiling 1 per cent. hydric chlorid	480 calories
One gram of hay yields to boiling 1 per cent. sodic hydrate	887 calories
One gram of hay yields to treatment with chlorin, etc.	527 calories
One gram of hay yields a residue, cellulose	1017 calories
	4363 calories

TABLE XV.

CALORIFIC VALUE OF THE RESPECTIVE EXTRACTS OF ALFALFA HAY.

One gram of the alcoholic extract gives	4706 calories
One gram of the cold water, hot water and malt extract gives	3140 calories
One gram of the 1 per cent. hydric chlorid extract gives	3596 calories
One gram of the 1 per cent. sodic hydrate extract gives	5063 calories
One gram of the chlorin, etc. extract gives	5598 calories
One gram of the residue, cellulose, gives	4210 calories

TABLE XVI.

THE DRY FECES (ALFALFA HAY) GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

	Per cent.
Soluble in boiling 80 per cent. alcohol	13.405
Soluble in cold water	5.243
Soluble in hot water and malt	3.742
Soluble in boiling 1 per cent. hydric chlorid	13.961
Soluble in boiling 1 per cent. sodic hydrate	14.980
Soluble in chlorin, sodic hydrate and sulfurous acid	18.657
Residue, cellulose	30.012
	100.00

TABLE XVII.

THE CALORIFIC VALUE OF THE FECES (ALFALFA) AND THE VARIOUS RESIDUES.

The calorific value of the dry feces	4525 calories
The calorific value of the residue after extraction with 80 per cent. alcohol	4339 calories
The calorific of the residue after extraction with cold and hot water and malt	4373 calories
The calorific value of the residue after extraction with 1 per cent. hydric chlorid	4441 calories
The calorific value of the residue after extraction with 1 per sodic hydrate	4886 calories
The calorific value of the residue after extraction with chlorin, etc.	4294 calories

TABLE XVIII.

THE CALORIFIC VALUE REMOVED FROM THE FECES (ALFALFA HAY) BY THE SUCCESSIVE TREATMENTS.

One gram of dry feces yields to boiling 80 per cent alcohol	769 calories
One gram of dry feces yields to cold and hot water with aid of malt	362 calories
One gram of dry feces yields to boiling 1 per cent. hydric chlorid	567 calories
One gram of dry feces yields to boiling 1 per cent. sodic hydrate	449 calories
One gram of dry feces yields to chlorin, etc.	1090 calories
One gram of dry feces yields residue, cellulose	1288 calories

TABLE XIX.

THE CALORIFIC VALUE OF THE VARIOUS EXTRACTS OF THE FECES (ALFALFA HAY)

One gram of the alcoholic extract gives	5739 calories
One gram of the cold and hot water, etc., extract gives	4123 calories
One gram of the boiling 1 per cent. hydric chlorid gives	4061 calories
One gram of the boiling 1 per cent. sodic hydrate gives	2997 calories
One gram of the chlorin, etc., extract gives	5842 calories
One gram of the residue, cellulose, gives	4294 calories

TABLE XX.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA HAY.

	Heat Units Consumed	Heat Units Voided	Heat Units Appro.	Coefficient
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extract*	5,074,240	1,599,724	3,474,516	68.51
One per cent. hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
One per cent. sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,045,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

§65. The coefficients of digestibility of the heat values of the various extracts show the same general features exhibited by the preceding tables, showing , in particular, the high value of the portion soluble in 80 per cent. alcohol which furnishes the largest portion by weight of dry substance digested—over one-third of the total nitrogen digested and one-third of the total heat units appropriated. The sodic hydrate extract furnished, in the case of alfalfa the largest amount of nitrogen, one-half more than the alcoholic extract, less dry matter than either the cellulose or the alcoholic extract and one-fifth less heat than the alcoholic extract.

§66. The values of the extracts, measured by the heat furnished, stand as follows for alfalfa:—Alcoholic extract, 11 millions heat units; sodic hydrate extract, 8 millions; the insoluble portion of the fodder, the cellulose, 6 millions of heat units.

§67. This order does not hold good for the other fodders examined in this manner. The alcoholic extract and the cellulose constitute two of the three most important portions of the fodder, but the hydric chlorid extract stands above the sodic hydrate as a source of heat in the corn fodder.

TIMOTHY HAY.

§68. The timothy hay used was the best that we could obtain in the open market and was grown in the mountains.

§69. Though the hay appeared to be of excellent quality, the sheep did not do well on it, one sheep gained one-half pound in five

*The aqueous extract includes all that was dissolved out by cold water, 24 hours digestion, boiling with water for one hour and subsequently treating with malt extract.

days, the other two together lost one and a half pounds, leaving a net loss of one pound for the three sheep in five days. This is in strong contrast with the results obtained with the alfalfa and corn fodder. The sheep fed alfalfa all gained. The total gain for the three sheep was nine pounds in five days; those fed on corn fodder also all gained, the total gain in five days being three and one-half pounds, so we have 9 and 3½ pounds gain respectively for the alfalfa and corn fodder, against a net loss of one pound for the timothy hay. The coefficient of digestion for the dry matter in the alfalfa hay found by the ordinary method of determining it was 62.05, and by considering the extracts individually it was 62.55. In the case of the timothy hay, we obtained in the ordinary manner 51.03, in the manner here pursued 51.10, an excellent agreement in both cases with a difference of 11 per cent.in these coefficients, that of the alfalfa being the higer. The sheep consumed, however, 11,265 grams of dry matter, as alfalfa hay, leaving almost no orts and only 8,223 grams of dry matter as timothy hay, leaving 4,233 grams of orts.

TABLE XXI.

ANALYTICAL DATA. TIMOTHY HAY.

Proximate Analysis.

TIMOTHY HAY		CORRESPONDING FECES	
		Sheep No. 1	
Moisture	6.49	Moisture	6.79
Ash	9.37	Ash	7.84
Ether extract	2.99	Ether extract	2.28
Proteids	5.62	Proteids	5.92
Crude fibre	31.54	Crude fibre	37.26
Nitrogen-free extract	43.99	Nitrogen-free extract	39.91
	100.00		100.00

TABLE XXII.

ANALYSIS OF THE ASH.

TIMOTHY HAY		CORRESPONDING FECES	
Sand	26.249	Sand	43.943
Silicic acid	11.506	Silicic acid	9.126
Sulfuric acid	3.033	Sulfuric acid	1.515
Phosphoric acid	4.239	Phosphoric acid	11.428
Carbonic acid	5.390	Carbonic acid	1.259
Chlorin	7.177	Chlorin	0.798
Potassic oxid	30.118	Potassic oxid	10.721
Sodic oxid	0.146	Sodic oxid	1.122
Calcic oxid	5.586	Calcic oxid	11.981
Magnesic oxid	2.685	Magnesic oxid	3.868
Ferric oxid	0.540	Ferric oxid and Aluminic oxid	1.171
Alumnic oxid	0.176		
Manganic oxid	0.370	Manganic oxid	0.189
Ignition	(4.357)	Ignition	3.000
	101.617		100.121
Oxygen equivalent to Chlorin	1.617	Oxygen equivalent to chlorin	.180
	100.000		99.941

TABLE XXIII.

ULTIMATE ANALYSIS.

TIMOTHY HAY		CORRESPONDING FECES	
Carbon	44.241	Carbon	46.362
Hydrogen	5.832	Hydrogen	6.186
Nitrogen	0.892	Nitrogen	0.954
Sulfur	0.104	Sulfur	0.143
Chlorin	0.506	Chlorin	0.133
Ash	9.370	Ash	7.840
Oxygen (approx.)	39.045	Oxygen (approx.)	38.382
	100.000		100.000

§70. The ash in this analysis, of course, represents the thoroughly oxidized, non-combustible portion of the plant containing a considerable portion of both the chlorin and sulfur. The chlorin and sulfur given above are the quantities contained in the air-dried hay as obtained by direct determination. The percentage of ash as given is too high by the amount of the chlorin and sulfur retained which is from 92 to 98 per cent. of the total sulfur and chlorin respectively, and also by the oxygen which the ash constituents may have taken up. The percentage of oxygen is, for these reasons, retention of chlorin and sulfur and the possible absorption of oxygen by the ash constituents, too low, for which reason, I have designated it as approximate only.

TABLE XXIV.

ANALYSIS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	21.307	20.931	21.12
Cold water in 24 hrs. extracted	6.858	7.039	6.95
Hot water extracted	3.000	2.968	2.98
Hydric chlorid, 1 per cent. sol. extracted	19.740	20.717	20.23
Sodic hydrate, 1 per cent. sol. extracted	17.108	16.997	17.05
Chlorin, etc., extracted	5.548	5.872	5.71
Cellulose remaining	26.439	25.476	25.96
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.16	1.44	1.30
Sucrose in alcoholic extract	2.83	2.83	2.83
Gum in cold water extract	3.12	3.12	3.12
Starch in hot water extract	None	None	None
Reducing power calculated as Xylan in hydric chlorid extract	15.77	Lost	15.77
Reducing power calculated as Xylan in sodic hydrate extract	0.83		0.83

TABLE XXV.

ANALYSIS OF ORTS OF TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	22.952	23.194	23.07
Cold water in 24 hrs. extracted.....	4.034	4.447	4.24
Hot water extracted	2.895	2.461	2.68
Hydric chlorid, 1 per cent. sol. extracted	19.552	19.826	19.68
Sodic hydrate, 1 per cent. sol. extracted	Lost	14.680	14.68
Chlorin, etc., extracted		8.530	8.53
Cellulose remaining		27.120	27.12
			100.000

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	2.48	2.43	2.46
Sucrose in alcoholic extract.....	3.29	3.37	3.33
Gum in cold water extract.....	1.82	2.03	1.93
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	14.32	15.39	14.86
Xylan in sodic hydrate extract.....	Lost	1.31	1.31

TABLE XXVI.

ANALYSIS OF FECES OF SHEEP FED ON TIMOTHY HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted..	16.592	15.512	16.05
Cold water in 24 hrs. extracted.....	2.840	2.818	2.83
Hot water extracted	3.255	3.288	3.27
Hydric chlorid, 1 per cent. sol. extracted	16.230	16.802	16.52
Sodic hydrate, 1 per cent. sol. extracted	16.893	19.226	18.06
Chlorin, etc., extracted	14.272	11.563	12.92
Cellulose remaining	29.918	30.792	30.35
			100.00

SUGARS IN THE EXTRACTS

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gum in cold water extract.....	0.20	0.0	0.10
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	7.91	9.44	8.68
Xylan in sodic hydrate extract.....	2.25	2.06	2.15

TABLE XXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	3813.0	1036.5	1776.5	691.4	1085.1	61.08
Total cold water extract....	925.6	196.5	815.1	121.9	694.2	85.06
Total hot water and malt ext.	397.8	120.4	277.4	140.9	136.5	49.21
Total hydrochloric acid 1% extract	2694.4	884.2	1810.2	711.6	1098.6	60.69
Total sodic hydrate (1 per per cent.) extract.....	2270.9	659.8	1511.1	777.9	733.2	48.52
					Excess	
Total chlorin, etc., extract..	760.6	383.0	377.6	556.5	—173.9	——
Total cellulose, residue, ...	3457.7	1218.3	2239.3	1307.4	931.9	41.61
Total	13320.0	4492.7	8808.2	4307.6	4500.6	51.10

Average coefficient of digestion for dry matter given page 29, Bulletin No. 93, 51.03.

TABLE XXVIII.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN TIMOTHY HAY AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts	Consumed.	Voided.	Digested.	Coef.
In the alcoholic extract:						
Glucose	173.2	110.5	62.7	0.0	6.27	100.00
Sucrose	377.0	149.6	227.4	0.0	227.4	100.00
In the cold water extract,						
Gums, etc.	415.6	86.7	328.9	4.3	324.6	98.69
In the hot water and malt extract, (starch)	0.0	0.0	0.0	0.0	0.0	——
In the 1 per cent. hydrochloric acid (Xylan) extract ...	2100.6	667.6	1433.0	373.9	1059.1	72.23
In the 1 per cent. sodic hydrate					Excess	
(Xylan) extract	110.5	58.9	51.6	92.6	41.0	——

§71. The furfurol in timothy hay was found to be 12.17 per cent. and there was accordingly 1,621.0 grams fed. The orts contained 11.60 per cent. equal to 521.2 grams and the feces contained 12.73 per cent., equal to 548.4 grams. This gives us 50.12 per cent. for the coefficient of digestion of the furfurol.

§72. I have used the furfurol instead of the complexes yielding it as we know quite certainly that there are probably several compounds present which may yield furfurol. Our coefficient, 50.12, shows no more than that one-half of the furfurol has been digested. If the complexes from which this is derived yield the same amounts of furfurol and are broken down with equal readiness, in the alimentary tract of the animal and by the distillation with the twelve per cent. acid, we would be justified in assum-

ing that one-half of the furfurol yielding substances are available as food for the ruminant. This is probably not far from the facts in the case, but it will be seen from the following table that we have very good reasons for doubting whether the complexes are equally attacked as we assume in making this statement.

TABLE XXIX.

FURFUROL IN THE VARIOUS EXTRACTS OF TIMOTHY HAY AND COEFFICIENTS OF DIGESTION.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	86.6	42.7	43.7	13.4	30.5	69.47
Cold water	122.7	17.5	105.2	30.5	74.7	71.07
Hot water	26.6	9.0	17.6	34.5	(—16.9)	———
Hydric Chlorid	542.7	186.9	355.8	263.1	92.7	32.80
Sodic hydrate	456.8	151.0	305.8	270.5	35.3	11.54
Clorin	129.2	39.1	90.1	1.3	88.8	98.54
Cellulose	271.7	74.6	197.1	98.2	98.9	50.12
			1115.5	711.2	404.3	36.24

§73. The results in this table are unsatisfactory, but we repeated a number of the determinations and found no error. The discrepancy between the coefficient found by summing up the amounts in the individual extracts of the hay, orts and dung and that found by determining the furfurol in the hay, orts and dung themselves is altogether too great, but the amount digested in either case is comparatively small and large differences result from comparatively small errors in the work. The general coefficient found was 50.12.

COEFFICIENT OF DIGESTION OF THE METHOXYL GROUP IN TIMOTHY HAY.

§74. The orts, as in the case of the alfalfa, have been considered as containing the same percentage of methoxyl as the hay, which is probably not correct, but this error can be neglected as the difficulties of the determination do not permit of great accuracy at the best. The hay consumed contained 124.20 grams; there was voided 103.70 grams; digested 20.5 grams, or 16.50 per cent.

DIGESTIBILITY OF THE AMIDS IN TIMOTHY HAY.

§75. The amid nitrogen found in the timothy hay used, corresponded to 0.99 per cent. of proteids, or 0.168 per cent. nitrogen and that found for the orts was almost identical, 0.994 per cent.; in the feces we found none. According to this the amid nitrogen is wholly digestible.

§76. This result is aparently not in accord with the results given under the next caption, but we found no amid nitrogen in the

feces of sheep fed on timothy hay, native hay, corn fodder or salt-bush, that is to say, we found no nitrogen in these samples which was not precipitated by cupric hydrate.

TABLE XXX.

COEFFICIENTS OF DIGESTION OF THE PROTEIDS IN THE VARIOUS EXTRACTS OF TIMOTHY HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	187.81	35.04	152.77	24.12	128.65	82.30
Proteids soluble in cold and hot water	82.58	41.78	40.80	53.41	(—12.61)	....
Proteids soluble in 1% hydric chlorid	98.57	33.25	65.32	42.65	22.67	34.71
Proteids soluble in 1% sodic hydrate	350.31	126.69	223.62	92.61	136.01	58.59
Proteids soluble in chlorin	13.23	10.78	2.45	37.48	(—35.03)	....
Proteids in residue, cellulose	9.32	2.70	6.62	6.89	(—0.27)	....
Total	741.82	250.24	491.58	257.16	234.42	47.69

The general coefficients of digestibility found for the three individual sheep were 47.73, 41.06 and 41.27. Average 43.35.

CALORIES CONSUMED AND VOIDED.

§77. We find the calorific value of dry timothy hay to be 4,414 and 4,417, an average of 4,415 plus; the orts gave 4,392 and the feces 4,709 calories.

§78. The dry matter fed contained 54,979,995 calories; the orts contained 18,586,944 calories and the feces 18,986,688 calories, which indicates the use of 47.83 per cent. of the heat energy of the fodder, or 17,406,363 calories.

§79. This timothy hay proved to be a poor fodder for sheep when fed alone. Two of the sheep lost weight and the third one gained one-half pound between the two weighings.

§80. We did not carry our calorimetric work further with timothy hay for the reason that this hay has been made the subject of study by others. Quite an exhaustive study of it is to be found in the Report of the Pennsylvania State College for the year 1903 and 1904.

NATIVE HAY.

§81. This hay is made up of a mixture of grasses and represents a fodder which is prized by many as an excellent one. The mixture of grasses varies greatly even in hay from the same farm. The results obtained in experiments with this hay are therefore applicable to other samples of it in a general way only, and it is for

this reason that we have not determined the heat value of the residues, obtained by extracting the hay with the various solvents adopted in this work.

TABLE XXXI.

ANALYTICAL DATA FOR NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES Sheep No. 6.	
Moisture	5.13	Moisture	5.96
Ash	10.64	Ash	12.41
Ether extract	3.13	Ether extract	5.02
Proteids	6.98	Proteids	5.48
Crude fibre	31.38	Crude fibre	29.29
Nitrogen-free extract	42.74	Nitrogen-free extract	41.84
	100.00		100.00

TABLE XXXII.

ANALYSIS OF ASH IN NATIVE HAY.

ASH OF NATIVE HAY		ASH OF CORRESPONDING FECES	
Carbon	Heavy trace	Carbon	———
Sand	3.375		
Silicic acid	54.736	Sand and Silicic acid	73.913
Sulfuric acid	1.521	Sulfuric acid	0.884
Phosphoric acid	2.133	Phosphoric acid	3.156
Carbonic acid	4.871	Carbonic acid	2.849
Chlorin	4.878	Chlorin	0.347
Potassic oxid	17.786	Potassic oxid	5.373
Sodic oxid	0.640	Sodic oxid	0.845
Calcic oxid	6.180	Calcic oxid	7.587
Magnesic oxid	2.016	Magnesic oxid	1.477
Ferric oxid	0.685	Ferric oxid	0.280
Aluminic oxid	0.273	Aluminic oxid	0.266
Manganic oxid	0.132	Manganic oxid	0.210
Ignition	1.719	Ignition	(2.891)
	100.945		100.078
Oxygen equivalent to chlorin	1.099	Oxygen equivalent to chlorin	0.078
	99.846		100.000

TABLE XXXIII.

ULTIMATE ANALYSIS OF NATIVE HAY.

NATIVE HAY		CORRESPONDING FECES	
Carbon	43.814	Carbon	45.328
Hydrogen	5.792	Hydrogen	5.935
Nitrogen	0.996	Nitrogen	0.919
Sulfur	0.116	Sulfur	0.109
Chlorin	0.673	Chlorin	0.073
Ash	10.640	Ash	12.410
Oxygen, (approx.)	27.969	Oxygen, (approx.)	25.226
	100.000		100.000

§82. The ash analysis of this hay shows a very high percentage of silicic acid. It is a well known fact that the ash of some of the grasses contain a large amount of silica, but this ash is as high or even a little higher than the superior limit usually found. This ash, when evaporated to dryness with hydric chlorid and subsequently treated with water, leaves a felt-like mass of silicic acid which is made up of quadrangular plates with irregular margins. If a stem of this hay be treated with hydric nitrate and potassic chlorate, to destroy the tissues and remove the soluble salts, and then be burned, one can obtain a beautiful skeleton of silica showing the outlines of the epidermal cells and the stomata. The total ash amounts to a little over one-tenth of the weight of the hay, and over one-half of this is silicic acid. The skeleton thus obtained seems to show that the stem is completely sheathed in a siliceous covering. The leaves also furnish skeletons, but these differ considerably in their details from the skeletons of the stems. The silica, however, seems quite abundant in the leaves, almost as much so as in the stems. This blue stem feels harsh to the touch, not so much so, perhaps, as the sedges, but the skeletal silica seems to be even more abundant in the blue stem than in the sedges.

§83. The coefficient of digestion found for this ash, 42.52, seems to be very high, too high in fact, but the separation of the silicic acid and sand in the ash of the feces was particularly difficult.

TABLE XXXIV.

PROXIMATE ANALYSIS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	21.469	21.537	21.50
Cold water, in 24 hrs., extracted.....	5.917	5.813	5.87
Hot water extracted	2.975	2.726	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.544	21.049	20.80
Sodic hydrate, 1 per cent. sol., extracted	16.485	16.816	16.64
Chlorin, etc., extracted	5.586	4.868	5.23
Cellulose, residue	27.024	27.191	27.11
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.38*	1.38	1.38
Sucrose in alcoholic extract	2.89	2.89	2.89
Gums in cold water extract	2.50	2.50	2.50
Starch in hot water extract	1.10	1.12	1.11
Reducing power expressed as Xylan, hydric chlorid extract.....	12.53	12.53	12.53
Reducing power expressed as Xylan, sodic hydrate extract.....	Trace	Trace	Trace

*We experienced more trouble than usual with this sample, so I have used averages of several pairs. The results are only approximately correct.

TABLE XXXV.

ANALYSIS OF ORTS OF NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	23.377	24.256	23.82
Cold water, in 24 hrs., extracted.....	5.899	5.197	5.55
Hot water extracted	2.999	2.701	2.85
Hydric chlorid, 1 per cent. sol. extracted	20.062	20.066	20.06
Sodic hydrate, 1 per cent. sol., extracted	16.917	16.922	16.92
Chlorin, etc., extracted	7.359	7.772	7.57
Cellulose, residue	23.387	23.086	23.23
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	1.54*		1.54
Sucrose in alcoholic extract	1.72		1.72
Gums in cold water extract	2.83		2.83
Starch in hot water extract	1.12		1.12
Xylan in hydric chlorid extract.....	12.53		12.53
Xylan(?) in sodic hydrate extract....	1.28		1.28

TABLE XXXVI.

DUNG OF SHEEP FED ON NATIVE HAY.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	17.430	17.928	17.68
Cold water, in 24 hrs., extracted.....	3.090	3.251	3.17
Hot water extracted	3.351	3.880	3.62
Hydric chlorid, 1 per cent. sol. extracted	15.538	15,230	15.38
Sodic hydrate, 1 per cent. sol., extracted	23.011	22.387	22.70
Chlorin, etc., extracted	9.288	9.078	9.18
Cellulose, residue	28.292	28.246	28.27
			100.00
SUGARS IN THE EXTRACTS			
Glucose in alcoholic extract	None	None	None
Sucrose in alcoholic extract	None	None	None
Gums, etc., in cold water extract.....	Trace	Trace	Trace
Starch in hot water extract	None	None	None
Xylan in hydric chlorid extract.....	10.13	9.07	9.60
Xylan(?) in sodic hydrate extract...	2.22	2.28	2.25

*This analysis, like that of the hay, was exceedingly unsatisfactory, though done in duplicate and repeated by two different operators.

TABLE XXXVII.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract.....	2834.1	618.7	2215.4	918.2	1297.2	58.55
Total cold water extract...	773.8	144.2	629.6	164.6	465.0	73.86
Total hot water and malt extract	375.7	74.0	301.7	188.0	113.7	37.69
Total hydric chlorid extract	2741.9	521.0	2220.9	798.7	1422.2	64.04
Total sodic hydrate extract	2193.5	439.5	1754.0	1178.9	575.1	32.79
Total chlorin, etc., extract.	689.4	196.6	492.8	476.7	16.1	3.28
Residue, cellulose	3573.6	603.3	2970.3	1468.1	1502.2	50.57
	13182.0	2597.3	10584.7	5193.2	5391.5	50.94

Average coefficient given for dry matter, Bulletin 93, page 32, 50.53.

TABLE XXXVIII.

COEFFICIENT OF DIGESTION FOR THE CARBOHYDRATES IN NATIVE HAYS, AS INDICATED BY THE SUGARS OBTAINED FROM THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract.	181.9	40.0	141.9	0.0	141.9	100.00
Sucrose in alcohol extract...	381.0	44.7	336.3	0.0	336.3	100.00
Gums in cold water extract	329.6	73.5	256.1	Trace	256.1	100.00
Starch in hot water and Malt extract	146.3	29.1	117.2	0.0	117.2	100.00
Xylan in hydric chlorid ext.	1651.7	325.4	1326.3	496.3	830.0	62.58
Xylan(?) in sodic hydrate extract	147.6	29.1	118.5	116.8	1.7	1.43
	2838.1	541.8	2296.3	613.1	1683.2	73.30

TABLE XXXIX.

COEFFICIENTS OF DIGESTION OF THE FURFUROL IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcohol	107.6	51.3	56.3	21.4	34.9	61.91
Cold water ..... } Hot water ..... }	87.3	40.2	47.1	43.9	3.2	6.79
Hydric chlorid, 1% Sol.....	711.6	102.7	608.9	240.7	368.2	44.04
Sodic hydrate, 1% Sol.....	359.7	51.6	308.1	178.2	129.9	42.16
Chlorin	126.9	17.6	109.3	121.9	-12.6	....
Cellulose	269.0	49.9	219.1	54.9	164.2	74.94
	1662.1	313.3	1348.8	661.0	687.8	50.99

§84. The coefficient of digestion found by calculating the furfurol in the hay fed, subtracting that contained in the orts, etc.,

is 50.63, which is in good agreement with that obtained by taking the sum of the separate extracts.

TABLE XL.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF NATIVE HAY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Proteids soluble in 80% alcohol	230.69	47.53	183.16	66.47	116.69	63.71
Proteids soluble in cold water and hot water and malt	69.86	18.96	50.90	35.83	15.07	29.61
Proteids soluble in 1% hydric chlorid	97.55	23.12	74.43	27.52	46.91	63.03
Proteids soluble in 1% sodic hydrate	383.60	59.48	324.12	129.82	194.30	58.58
Proteids soluble in chlorin,	29.00	4.93	24.07	27.01	—2.94	——
Proteids remaining in the cellulose	10.55	2.08	8.47	11.95	—3.48	——
	821.25	156.10	665.15	298.60	366.55	55.11

§85. The average coefficients of digestion found for the proteids in native hay, using three sheep, was 62.33, Colorado Experiment Station Bulletin No. 93, page 32.

HEAT VALUE OF NATIVE HAY.

§86. The energy was found to be equal to 4,349 calories for the dry hay and that of the dried feces was found to be 4,579 calories. The calorific value of the fodder consumed was 46,034,165 calories, that of the feces 23,778,747 calories; accordingly the animals appropriated 22,255,418 calories, or 48.34 per cent. of the total energy.

§87. The heat values or energy of the different extracts were not determined because, as stated in the description of this hay, it is made up of a mixture of grasses, sedges, etc., which varies so that this sample cannot be taken as representative except in a general way.

AMID NITROGEN.

§88. The proteids corresponding to the amid nitrogen in native hay amounted to 0.513 per cent., but we were unable to find any in the feces, consequently we infer that they were wholly digestible. The better way to put this is that the quantity of amid nitrogen is so small that, as a fodder constituent, it is wholly negligible.

METHOXYL GROUP IN NATIVE HAY.

§89. This group is present in the hay to the extent of 1.795 per cent., and in the feces to the extent of 2.764 per cent. The hay

consumed was 10,585 grams, and the feces voided 5,193 grams, which gives us a coefficient of 23.47 for the digestibility of this group in the hay.

§90. The results obtained in feeding this hay were fairly good, the net result being a gain of three and one-half pounds during the five days between the weighings. The dry matter voided in the feces was almost one-half of that consumed, and the coefficients of digestion were found to be comparatively low. This hay, designated as native hay, commands a high price and is held in high esteem, particularly for horses.

§91. In this experiment no grain or other fodder than the hay was fed. I wished to study the hay and not to determine an advantageous ration, of which it should be a part.

§92. If we compare the data furnished by the results obtained with alfalfa and those obtained in the case of the native hay, we observe very great differences. In the first place, the alfalfa is evidently a more palatable food to sheep than this hay or timothy. There was fed of the native hay, 13,182 grams, the sheep left 2,596 grams; of the alfalfa, 13,350 grams, of which 987 grams were left; of the timothy, 13,320 grams, of which 4,493 grams were left. These hays were all cut in order to induce the sheep to eat it up clean as possible. Sheep prefer, for instance, the leaves of alfalfa to the stems, and I wished to force them to eat the stems as well as the leaves.

TABLE XLI.

THE AMOUNT OF THE RESPECTIVE EXTRACTS DIGESTED AND THEIR COEFFICIENTS OF DIGESTION.

	Native Hay		Alfalfa Hay	
	Grams digested	Coefficients	Grams digested	Coefficients
Alcohol, 80%	1297.	58.55	2520.	68.64
Cold water	465.	73.86	846.	78.89
Hot water	114.	37.69	381.	70.24
Hydric chlorid	1422.	64.04	912.	60.20
Sodic hydrate	575.	32.79	1359.	67.72
Chlorin	16.	3.28	274.	25.39
Cellulose	1502.	50.57	1442.	52.67

§93. In regard to the relative amounts of the extracted matter digested and corresponding coefficients, we observe that much larger amounts of those substances dissolved out by the eighty per cent. alcohol, cold and hot water, the latter with addition of malt ex-extract, were digested in the case of the alfalfa than in that of the native hay, and the coefficients of digestion are materially higher. The reverse is the case with those substances dissolved out by the one per cent. hydric chlorid, the quantity digested, as well as the

coefficient of digestion, being higher in the case of native hay than in that of the alfalfa. The amount of digestible matter removed from alfalfa by the one per cent. solution of sodic hydrate is greater, about 2⅓ times, than that removed from the native hay. The matter removed by chlorin, etc., is neither considerable in quantity, nor does it appear to be very digestible. The amounts of cellulose digested were approximately the same in the two cases, as are also the coefficients of digestion.

§94. The most important fact to be kept in mind in this comparison is that the same sheep when fed these hays made a uniform gain of three pounds in five days on the alfalfa, or a net gain of nine pounds, whereas two gained one-half pound each and one two and a half pounds in five days, a net gain of three and one-half pounds, when fed the native hay. It may be futile to seek an explanation of these results in the analytical data, but it is the purpose of this bulletin to present the latter as fully as we are at present able to, in order to see whether this may in any way be possible. An examination of the amounts of the various extracts digested and their coefficients of digestion would lead us, possibly justly so, to attach great importance to the alcoholic and sodic hydrate extracts, especially as the latter solvent is supposed to remove the principal portion of the nitrogenous compounds to which we are accustomed to attach great value.

§95. It may be that these two extracts, those obtained by alcohol and sodic hydrate, respectively, do stand in some immediate relation to the respective values of the two hays, but some facts to be presented subsequently in connection with another fodder, while not showing that the above inference is wrong, will lead us to hesitate in drawing conclusions too freely.

§96. The substances removed by chlorination, including subsequent treatment with sodic hydrate and sulfurous acid, was 16 grams in the case of the native hay, 274 grams in that of the alfalfa, the former having a coefficient of 3.28 per cent., and the latter 25.39 per cent., both very low. The residue, which I have designated as cellulose though I know it is not pure, amounts to 1,502 grams in the native hay and 1,442 grams in the alfalfa, much more nearly equal than one would expect. The same, too, being true of the coefficients of digestion, as we find 50.57 for the cellulose from the native hay and 52.67 for that from the alfalfa.

§97. If we study the distribution of the nitrogen in the various extracts and the coefficients of digeston obtained, we find even greater differences, because we deal with smaller numbers and there is, too, a marked difference in the quantity of this element in the two fodders, the alfalfa being much the richer, containing almost 24 times as much nitrogen.

TABLE XLII.

The following figures represent grams of proteids (N. x 6.25).

DIGESTIBILITY OF THE PROTEIDS IN THE RESPECTIVE EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcohol, 80%	115.0	62.98	486.0	81.77
Cold water, hot water and malt	16.0	32.34	63.0	25.91
Hydric chlorid, 1%	57.0	67.34	132.0	72.38
Sodic hydrate, 1%	184.0	58.63	649.0	80.89
Chlorin, etc.	———	———	12.0	30.19
Cellulose	———	———	3.0	16.48

§98. We have not only a very much larger amount of proteids in the alfalfa, but also very much higher coefficients of digestion. Both hays show that sodic hydrate and alcohol are the two solvents removing the nitrogen. The hydric chlorid standing third in the list, removing one-half as much from the native hay and almost one-third as much from the alfalfa as the alcohol.

§99. In this connection the amid nitrogen should probably be considered; at least, the relative amounts in the hays should be given. The alfalfa consumed contained amid nitrogen corresponding to 337.45 grams proteids, with a coefficient of digestion of 81.55. The native hay contained an amount corresponding to 54.29 grams, the whole of which was digested, as no amid nitrogen was found in the feces.

§100. If we next compare the sugars contained in these two hays, we will find still other differences.

TABLE XLIII.

DIGESTIBILITY OF THE CARBOHYDRATES, MEASURED BY THE REDUCING POWER OF THE INVERTED EXTRACTS.

	Native Hay		Alfalfa Hay	
	Grams	Coefficients	Grams	Coefficients
Alcoholic extract, Sucrose	142.0	100.00	159.0	100.00
Alcoholic extract, Glucose	336.0	100.00	110.0	100.00
Cold water, gums, etc	256.0	100.00	83.0	81.09
Hot water and malt, starch	117.0	100.00	145.0	93.73
Hydric chlorid, 1% invert. sugar	830.0	62.58	286.0	83.96
Sodic hydrate, 1% invert. sugar, very minute quantity.				

§101. Except in the case of sucrose and starch, we find that the native hay contains more of these substances, or complexes yielding them, than the alfalfa. The most marked instance is the reducing power yielded by the hay on being treated with the one per cent. hydric chlorid, whereby hydrolysis effected the production of sugar equal to 1,326 grams of xylan, of which 830 grams were digested, whereas, in the alfalfa, the same treatment produced 340

grams galactan, of which 286 grams or 83.96 per cent. were digested. The differences here are quite marked and, so far as the quantity digested is concerned, apparently in favor of the native hay.

§102. If we, in like manner, compare the results obtained by determining the furfurol, we will observe that other differences are strongly indicated.

TABLE XLIV.

FURFUROL DIGESTED.

	Native Hay		Alfalfa Hay	
	Grams digested	Coefficients	Grams digested	Coefficients
Alcoholic extract	35.0	61.99	133.0	96.51
Cold water	3.0	6.79	78.0	100.00
Hot water and malt			67.0	67.44
Hydric chlorid, 1%	268.0	44.04	189.0	100.00
Sodic hydrate, 1%	130.0	42.16	55.0	27.81
Chlorin, sodic hydrate, etc.	....	.....	....	.....
Cellulose	164.0	74.94	171.0	72.62

§103. We observe that the furfurol yielding substances in these two fodders must be very different. Those removed by alcohol, water and hydric chlorid from the alfalfa hay having a much higher coefficient of digestion than those dissolved out of the native hay, while the furfurol yielding bodies removed by the one per cent. sodic hydrate from the alfalfa show a low coefficient of digestion, much lower even than the corresponding substances in the native hay. When we come to the portion that I have designated cellulose, we find the amount of furfurol digested in the two cases and also the coefficients of digestion very close together, so that this factor would apparently fall out of our consideration. The same is indicated by the amount of cellulose digested in these two cases, the three sheep having digested 1,441 grams cellulose fed as alfalfa and 1,502 grams fed as native hay. As pure cellulose yields from 2 to 2.5 per cent. of furfurol, and we obtained for the alfalfa cellulose 1.919 and for that from the native hay, 2.041 per cent. furfurol, the two products are probably almost pure cellulose, and the above results in regard to the cellulose are such as we should expect.

§104. In the case of the native hay, we find that the coefficients of digestion for the furfurol are low, except in the case of that yielded by the cellulose. The most marked features are the deportment of those compounds yielding furfurol, but which are soluble in one per cent. solutions of hydric chlorid or sodic hydrate. Such substances removed from alfalfa by one per cent. hydric chlorid seem to be wholly digestible, while those removed by the sodic hydrate are only slightly digestible. The alfalfa consumed contained substances soluble in the one per cent. hydric chlorid, which

yielded 189 grams furfurol, while those soluble in one per cent. sodic hydrate yielded 202 grams of furfurol. Those substances present in the native hay soluble in one per cent hydric chlorid yielded a total of 609 grams of furfurol, of which 44.04 per cent. was digestible; those soluble in one per cent. sodic hydrate yielded 308 grams of furfurol, of which 42.16 per cent. was digestible. Another very marked difference between these fodders is the solubility of the substances yielding furfurol in the different media, the furfurol yielded by the cellulose not being considered in the following statements. Hydric chlorid removes from the native hay almost exactly one-half of the furfurol—coefficient 44.04—while it removes about one-quarter of it from the alfalfa, coefficient 100. Sodic hydrate removes from the native hay one-quarter of the furfurol, coefficient 42.16; from the alfalfa one-quarter, with a coefficient of digestibility of 27.81.

§105. The one per cent. sodic hydrate solution seems to remove very considerable amounts of material which is capable of yielding furfurol from both of these fodders, but we were unable to obtain more than minute quantities of reducing sugars in the inverted extracts, which is contrary to what we would expect if this furfurol is derived from pentosans.

§106. The heat values of these two hays, alfalfa and native hay, show more directly, probably, than any other factors their relative values. We find that the animals appropriated 30,519,751 calories when fed on alfalfa, and 22,255,418 calories when fed on the native hay. The same sheep were used in these two experiments, both made under favorable conditions, so that the questions of individualty, etc., are removed as far as far as possible. The net result was a gain of 9 pounds in the one case, alfalfa, and three and one-half pounds in the other, native hay.

§107. Other sheep were used in the experiment with timothy hay, but the conditions were as favorable as we could make them. The energy consumed was 17,406,363 calories, and the result was a net loss of one pound.

CORN FODDER.

§108. The fodder used was in good condition. The stalks were rather heavy for sheep feeding and the amount refused by them was, on this account, rather large. The corn was a variety of dent and had been grown in drills in which the seed had been thinly sown. The fodder was cut in lengths not exceeding one-half inch before feeding. The sheep ate it readily, but refused the heavier stocks, nor could we induce them to eat this portion by grinding it. Each of the three sheep used in this experiment gained weight while being fed on it. No other food was fed in connection with it. The

coefficients of digestion for this fodder were found to be quite good, excepting that that for the proteids was much below the average, as we found 36.04 as the coefficient of digestibility for these substances, whereas the average found by other experimentors is 56.1. The total proteids in this fodder is slightly above the average. I know of no reason for the low coefficient, but I have elsewhere observed that the coefficients obtained by us are apt to be below those found by others, due, probably, to the conditions under which our fodders are preserved.

TABLE XLV.

ANALYTICAL DATA FOR CORN FODDER.

FODDER ANALYSIS.

CORN FODDER.		CORRESPONDING FECES. Sheep No. 1.	
Moisture	8.21	Moisture	6.73
Ash	9.53	Ash	12.63
Ether extract	1.55	Ether extract	1.12
Proteids	4.62	Proteids	7.16
Crude fibre	29.85	Crude fibre	30.16
Nitrogen-free extract	46.24	Nitrogen-free extract	42.20
	100.00		100.00

TABLE XLVI.

ANALYSIS OF THE ASH.

CORN FODDER.		CORRESPONDING FECES.	
Sand	13.048	Sand	23.796
Silicic acid	19.812	Silicic acid	38.867
Sulfuric acid	1.313	Sulfuric acid	1.063
Phosphoric acid	5.199	Phosphoric acid	5.158
Carbonic acid	10.319	Carbonic acid	0.060
Chlorin	3.495	Chlorin	0.571
Potassic oxid	28.366	Potassic oxid	3.626
Sodic oxid	2.603	Sodic oxid	0.759
Calcic oxid	6.090	Calcic oxid	10.625
Magnesic oxid	4.501	Magnesic oxid	6.500
Ferric oxid	1.530	Ferric oxid	1.909
Aluminic oxid	0.851	Aluminic oxid	1.343
Manganic oxid	0.260	Manganic oxid	0.170
Ignition	(3.401)	Ignition	5.685
	100.788		100.132
Oxygen equivalent to Cl	0.788	Oxygen equivalent to Cl	0.103
	100.000		100.029

TABLE XLVII.

ULTIMATE ANALYSIS.

CORN FODDER.		CORRESPONDING FECES.	
Carbon	42.661	Carbon	42.754
Hydrogen	5.892	Hydrogen	5.494
Nitrogen	0.739	Nitrogen	1.145
Sulfur	0.099	Sulfur	0.133
Chlorin	0.342	Chlorin	0.152
Ash	9.530	Ash	12.630
Oxygen (approx.)	40.737	Oxygen (approx.)	37.692
	100.000		100.000

§109. The chlorin and sulfur determinations were made on the fodder and not calculated from the ash. The oxygen percentage is only approximate, as the ash contains most of the sulfur and chlorin and probably oxygen taken up during the burning, and these elements enter the analysis in part, at least twice.

§110. The ratio of the air-dried feces to the weight of air-dried fodder consumed is 1:2.33; in the case of alfalfa it is 1:2.7. The portion of the corn fodder left by the sheep amounted to 24 per cent. of the fodder, while the portion of alfalfa left amounted to 7.38 per cent. This difference is considerable when considered in pounds only, but when the character of the two fodders is taken into consideration, the proportion of the corn fodder consumed seems quite favorable. The ratio of the leaves in this fodder to the stems was 2:1, which is not very different from the ratio of leaves to stems in the alfalfa plant, but the corn stalk is very different from the alfalfa stem. Sheep will not eat the alfalfa stems when they are coarse; this is probably due to the hardness of the stems, but, in the case of the corn stalks, they will not eat them even when they have been ground. The results show that only about 10 per cent. or even less of the corn stalks was eaten when cut in lengths of from ¼ to ½ inch. The fodder had been cut close to the ground, so that the whole of the plant was represented in the fodder.

§111. It was hoped that the elementary analyses of the fodders might show some differences suggestive of the wide differences in their actual feeding values, but the range in the ultimate composition of both the fodders and the feces shows that they are of but little value for the purposes of this study, as they show nothing more, that we can interpret, than the fodder analysis.

TABLE XLVIII.

CORN FODDER.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	29.243	29.985	29.614
Cold water, 24 hours, extracted.....	4.350	4.827	4.589
Hot water and malt extracted.....	3.881	2.603	3.241
Hydric chlorid, 1% sol. extracted.....	19.550	20.244	19.897
Sodic Hydrate, 1% sol. extracted.....	13.891	13.692	13.792
Chlorin, etc., extracted	3.075	4.020	3.547
Cellulose	26.010	24.630	25.320
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	5.24	5.29	5.26
Sucrose in alcoholic extract.....	4.44	4.09	4.27
Gums in cold water extract.....	0.58	0.45	0.52
Starch in hot water extract.....	None	None	None
Xylan* in hydric chlorid extract.....	12.07	10.88**	12.07
Xylan in sodic hydrate extract.....	0.72	0.63	0.63

TABLE XLIX.

CORN FODDER ORTS.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol.....	28.429	27.978	28.20
Cold water, 24 hours.....	2.538	3.379	2.96
Hot water	2.657	1.985	2.32
Hydric chlorid 1% sol.	20.149	20.584	20.37
Sodic hydrate, 1% sol.	14.590	15.443	15.02
Chlorin, etc.	3.626	3.684	3.66
Cellulose	28.011	26.947	27.48
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	8.48	8.79	8.64
Sucrose in alcoholic extract.....	2.35	2.49	2.42
Gums in cold water extract.....	0.47	0.47	0.47
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract†.....	16.32	17.02	16.67
Xylan in sodic hydrate extract.....	0.86	0.73	0.80

*There is some galactan present, in two trials we obtained 0.680 and 0.706%. Other trials did not agree in quantity but all showed presence of galactan. Galactan is easily hydrolyzed. This extract is not. The feces also gave a slight precipitate for mucic acid.

**Rejected, inversion incomplete.

†According to the mucic acid determination, there is a small amount of galactan present, but the 16.32% of sugar present is so large that I have calculated it all as Xylan.

TABLE L.

CORN FODDER FECES.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	16.71	16.27	16.50
Cold water, 24 hours, extracted.....	4.38	4.66	4.53
Hot water and malt extracted.....	3.70	3.31	3.51
Hydric chlorid, 1% sol. extracted....	13.49	14.99	14.24
Sodic Hydrate, 1% sol. extracted.....	23.55	Lost	23.55
Chlorin, etc., extracted	11.12		11.12
Cellulose	26.55		26.55
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.36	0.36	0.36
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	2.23	3.23	2.73
Xylan in sodic hydrate extract.....	2.44	Lost	2.44

TABLE LI.

CORN FODDER—COEFFICIENTS OF DIGESTION OF THE VARIOUS EXTRACTS.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Alcoholic extract 3461.4		737.2	2424.2	635.4	1788.8	73.79
Cold water extract..... 536.4		77.4	459.0	174.4	284.6	54.16
Hot water and malt ext... 378.8		60.6	318.2	135.2	183.0	54.37
Hydric chlorid, 1% extract. 2325.7		532.5	1793.2	548.4	1244.8	69.42
Sodic hydrate, 1% extract. 1612.1		392.7	1219.4	877.1	342.3	36.27
Chlorin, etc. 414.1		95.8	318.3	431.7	(—113.4)	
Cellulose 2959.5		718.4	2241.1	1030.9	1210.2	54.00
			8773.41	3833.1	4940.3	56.31

The general coefficient of digestion for the dry matter in corn fodder was found to be 56.66 per cent.

TABLE LII.

CARBOHYDRATES IN CORN FODDER AND THEIR COEFFICIENTS OF DIGESTIBILITY.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose	656.9	225.9	431.0	0.0	431.0	100.00
Sucrose	499.1	58.6	440.5	0.0	440.5	100.00
Gums, etc.	60.8	12.3	48.5	13.8	34.7	71.56
Starch	0.0	0.0	0.0	0.0	0.0	——
Xylan, 1% hydric chlorid..	1410.8	435.8	975.0	105.1	869.9	89.22
Xylan(?) 1% sodic hydrate	73.6	20.9	52.7	94.0	(-41.3)	——
Cellulose 2959.5		718.4	2241.1	1030.9	1210.9	54.00

TABLE LIII.

FURFUROL FOUND IN CORN FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Cornfodder Per cent.	Orts Per cent.	Feces Per cent.
Original	11.476	10.625	10.997
Residue after treatment with 80% alcohol	10.792	10.530	10.894
Residue after treatment with cold water	10.768	same	same
Residue after treatment with hot water and malt	10.394	same	same
Residue after treatment with 1% hydric chlorid	5.342	5.841	7.536
Residue after treatment with 1% sodic hydrate	2.636	2.655	3.350
Residue after treatment with chlorin, etc., Cellulose	1.799	1.649	Not det.

TABLE LIV.

COEFFICIENT OF DIGESTION OF FURFUROL IN CORN AND THE PORTION DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.*	Consumed.	Voided.	Digested.	Coef.
Corn fodder	1341.4	277.8	1063.6	423.5	640.1	60.20
Soluble in 80% alcohol	80.0	2.5	77.5	4.0	73.5	94.80
Soluble in cold water	2.8**	——	2.8	0.0	2.8	100.00
Soluble in hot water and malt	43.7	——	43.7	0.0	43.7	100.00
Soluble in 1% hydric chlorid	590.3	122.6	467.7	125.5	342.2	73.17
Soluble in 1% sodic hydrate	316.3	80.3	236.0	160.9	75.1	31.82
Soluble in chlorin, etc.	97.8	26.3	71.5	129.0	62.3	32.57
Remaining in the cellulose	162.9	43.1	119.8			
			1019.2		479.8	47.07

METHOXYL GROUP IN CORN FODDER.

§112. The average percentage of this group found in the fodder was 1.445, and in the feces 2.033. In discussing this group under the subject of alfalfa, I stated that the results were probably rather low, basing this judgment on the check results obtained on a commercial sample of quinine. This observation applies to all of the samples and particularly, perhaps, to this case, as the amount found in the feces is the lowest in the series.

§113. The assumption that the orts and fodder were so nearly alike that no material error is made by taking them as the same is probably wrong in this case, for the orts were nothing other than corn stalks, which were so hard that the sheep did not eat them. They consisted essentially of the hard parts of the stalk and pith.

*These orts consisted wholly of pieces of stalks too hard for the sheep to eat.

**This figure has, as will readily be understood, no value, but it is the result that we obtained.

§114. The amount of this group, methoxyl, consumed was 129.67 grams, that voided was 78.27 grams, digested 51.40 grams, percentage digested 39.64.

AMID NITROGEN IN CORN FODDER.

§115. The total amid nitrogen found was very small, that found in the fodder was 0.077 per cent., equal to 0.481 per cent. of proteids; that found in the orts was 0.045 per cent., equal to 0.281 per cent. of proteids. We found none in the feces. The total is very small, but it is evident that we have to attribute to it a coefficient of digestion of 100.00.

TABLE LV.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF CORN FODDER.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	248.96	33.20	215.76	74.46	141.30	65.49
Cold water	32.73	1.83	30.90	25.85	5.05	16.30
Hot water and malt....	26.89	3.40	23.49	21.22	2.27	9.66
1% hydric chlorid	79.48	9.41	70.07	42.44	27.63	39.43
1% sodic hydrate	115.71	16.73	98.98	110.72	(—11.74)	———
Chlorin, sodic hydrate and sulfurous acid ..	30.39	1.57	28.82	15.43	13.39	46.46
Remaining in cellulose..	5.85	1.05	4.80	4.24	0.56	11.67
	540.01	67.19	472.82	294.36	178.46	37.74

§116. The coefficients found for the three sheep were 37.18, 37.49, 33.45; average 36.04 per cent.

THE CALORIFIC VALUE OF CORN FODDER AND ITS VARIOUS EXTRACTS.

§117 The calorific value of the dry corn fodder was found to be 4,244 calories, and the total heat units fed amounted to 45,533,876; the total value of the feces was 15,258,816 calories; the total heat value of the orts was 10,850,880 calories; the sheep therefore appropriated 19,424,180 calories, or 56 per cent. of that consumed.

§118. The sheep gained weight, 3½ pounds, during the five days that the test lasted. The gain was for the different sheep 2, 1 and ½ pounds, respectively. The number of heat units appropriated by the sheep is less than in the case of the native hay, 22,255,418 calories, while the gain in weight is the same; the coefficient of digestion, however, is higher, it being in the case of the native hay 48.34 per cent., and in the corn fodder 56 per cent. In timothy hay it was 47.83 per cent., and the heat units appropriated by the sheep were 17,406,363. One of the sheep gained and two lost, resulting in a net loss of one pound for the three sheep:

Timothy hay, heat units appropriated, 17,406,363, loss 1.0 pounds.
Corn fodder, heat units appropriated, 19,424,180, gain 3½ pounds.
Native hay, heat units appropriated, 22,255,418, gain 3½ pounds.
The percentages of the heat units thus used by the sheep are 47.83, 56.00 and 48.34.

TABLE LVI.

The dry corn fodder gave the following extracts and residue:

	Per cent.
Soluble in 80% alcohol	23.32
Soluble in cold water	5.00
Soluble in hot water and malt	3.54
Soluble in 1% hydric chlorid	21.68
Soluble in 1% sodic hydrate	15.03
Soluble in Chlorin, etc.	3.86
Residue, Cellulose	27.57
	100.00

§119. The distribution of the ash in these extracts was not determined and, consequently, no correction has been made on account of it.

TABLE LVII.

The calorific values of the dry fodder and the respective residues were as follows:

	Calories.
The dry fodder	4244
Residue after extraction with 80% alcohol	4250
Residue after extraction with cold water Residue after extraction with hot water and malt	4405
Residue after extraction with 1% hydric chlorid	4459
Residue after extraction with 1% sodic hydrate	4201
Residue after extraction with chlorin, etc.	4134

TABLE LVIII.

CALORIES REMOVED BY THE SUCCESSIVE TREATMENTS.

One gram of corn fodder yields to 80% alcohol	985 calories
One gram of corn fodder yields to cold water One gram of corn fodder yields to hot water and malt	257 calories
One gram of corn fodder yields to 1% hydric chlorid	930 calories
One gram of corn fodder yields to 1% sodic hydrate	752 calories
One gram of corn fodder yields to chlorin, etc.	180 calories

TABLE LIX.

CALORIFIC VALUES OF THE EXTRACTS OF CORN FODDER.

One gram of alcoholic extract equals	4224 calories
One gram of cold water extract equals One gram of hot water and malt extract equals	3009 calories
One gram of 1% hydric chlorid extract equals	4290 calories
One gram of 1% sodic hydrate extract equals	5003 calories
One gram of chlorin, etc., extract equals	4665 calories
One gram of residue, cellulose, equals	4134 calories

TABLE LX.

The dry feces gave the following extracts and residue:

APPROXIMATE ANALYSIS OF THE DRY FECES.

	Per cent.
Soluble in 80% alcohol	10.48
Soluble in cold water	4.86
Soluble in hot water and malt	3.76
Soluble in 1% hydric chlorid	15.27
Soluble in 1% sodic hydrate	25.25
Soluble in chlorin, etc.	11.92
Residue, cellulose	28.46
	100.00

TABLE LXI.

The distribution of the ash was not determined.

THE CALORIFIC VALUES OF THE DRY FECES AND THE RESPECTIVE RESIDUES.

The calorific value of the dry feces equaled	4248 calories
Residue after extraction with 80% alcohol	4153 calories
Residue after extraction with cold water / Residue after extraction with hot water and malt	4252 calories
Residue after extraction with 1% hydric chlorid	4126 calories
Residue after extraction with 1% sodic hydrate	*3889 calories
Residue after extraction with chlorin, etc	3714 calories

TABLE LXII.

CALORIES REMOVED FROM THE FECES (CORN FODDER) BY THE SUCCESSIVE TREATMENTS.

One gram of feces yields to hot 80% alcohol	530 calories
One gram of feces yields to cold and hot water and malt	236 calories
One gram of feces yields to 1% hydric chlorid	774 calories
One gram of feces yields to 1% sodic hydrate	1138 calories
One gram of feces yields to chlorin, etc.	513 calories
One gram of feces yields a residue, cellulose	1057 calories
	4248 calories

TABLE LXIII.

CALORIFIC VALUES OF THE RESPECTIVE EXTRACTS OF THE FECES (CORN FODDER.)

One gram of the alcoholic extract equals	5057 calories
One gram of cold and hot water with malt equals	2738 calories
One gram of the 1% hydric chlorid extract equals	5069 calories
One gram of the 1% sodic hydrate extract equals	4507 calories
One gram of the chlorin, etc., extract equals	4304 calories
One gram of the residue, cellulose, equals	3714 calories

*We at first doubted this result, so another sample was started de novo and the determination repeated with the result that we obtained 3891 calories as the value of this residue.

TABLE LXIV.

COEFFICIENTS OF DIGESTION FOR THE FUEL VALUES OF THE VARIOUS EXTRACTS OF CORN FODDER.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
One per cent. hydric chlorid ext.	7,691,970	2,774,812	4,914,158	63.88
One per cent. sodic hydrate ext.	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract	1,482,734	1,859,328	(-376,594)	....
Residue or cellulose	9,264.294	3,829,138	5,435,160	58.67

ALFALFA AND CORN FODDER COMPARED FROM THE STANDPOINT OF THEIR CALORIMETRIC RELATIONS.

§120. The two fodders first chosen for a complete study were alfalfa and corn fodder. In making this choice, I considered the fact that alfalfa is, beyond all question, our best fodder and, after it, for general all round purposes, corn fodder, probably stands next. Timothy is grown in considerable quantities in some sections of the state, but it is too limited in supply, and too high in price to be thought of as a general fodder, either by itself or for the purpose of balancing an alfalfa ration, unless it be for horses. Timothy has further been studied, and from this standpoint would have been, in part at least, a repetition of other work. Our native hay is a very much better fodder than timothy hay, but the supply of it is limited, the price is high, and its composition is variable, *i. e.*, the grasses, rushes and sedges forming it vary with localities and seasons. I chose corn fodder because it can be produced cheaply in large quantities over a large territory and because the results of feeding indicate that it is as good a fodder as the native hay and a very much better one than timothy hay. I was, in short, guided by the consideration of the utility of the respective fodders. It would have been a mistake to do so to the exclusion of other fodders, as my object has really not been to study good, acceptable fodders, but to discover, if possible, the reasons why one fodder is better than another, why one is good and another poor. While the difference between the values of corn fodder and alfalfa is considerable, it is not wide enough to give the best opportunity for presenting such a study with thoroughly satisfactory results. We will find larger differences when we come to the study of the saltbush, *Atriplex argentea,* which is an exceedingly poor fodder.

§121. There are very salient and interesting contrasts between these two fodders, alfalfa and the saltbush, *Atriplex argentea,* which I may digress to state briefly. The sheep fed on alfalfa gained nine pounds; those fed on saltbush lost eight and one-half pounds in five days. It is true that the sheep to which alfalfa was

fed digested a larger amount of dry matter than those receiving saltbush, but not so much more as the difference of 17½ pounds of flesh would apparently indicate. The sheep receiving alfalfa digested 7,246 grams of dry matter, containing 1,315 grams of proteids, 3,274 grams of nitrogen-free extract and 1,875 grams of crude fibre; those receiving saltbush digested 7,051 grams of dry matter, containing 1,116 grams of proteids; 3,011 grams of nitrogen-free extract and 342 grams of crude fibre. The mineral matter contained in the saltbush and digested was very large, 2,315 grams against 779 grams digested with the alfalfa. These are the differences, total dry matter, 195 grams; crude proteids, 199 grams; nitrogen-free extract, 263 grams; crude fibre, 1,533 grams—all the differences so far being in favor of the alfalfa. In the case of the mineral matter, the sheep fed on the saltbush digested 1,536 grams more than those receiving alfalfa. The daily differences in the amounts digested per sheep for the various fodder constituents were as follows: Crude proteids 12.66 grams, nitrogen-free extract 17.5 grams, both in favor of the alfalfa-fed sheep, which were gaining six-tenths of a pound daily, while the saltbush-fed sheep were losing almost exactly the same amount. The only food element digested in considerable excess by the alfalfa-fed sheep, 102 grams daily per sheep, was the crude fibre. This may be the cause of the great difference in the results.

§122. It is not evident what part the mineral matter may have played, though the amount actually absorbed by the sheep was large, 2,315 grams for the three sheep in five days, it produced no looseness of the bowels or other inconveniences that we could observe. This fodder did provoke a marked thirst, but the sheep did not suffer on this account. It does not seem probable that the loss of flesh was due to the mineral constituents contained in the plant. If we may reason from analogy in this case, we would be justified in comparing its results with those produced by sugar beet tops, which contain from 22 to 30 per cent. of ash when dried. The compounds absorbed in the case of the saltbush appear to be the sulfuric acid, chlorin and the alkalies. In eating a like amount of dried sugar beet tops the animals would consume larger amounts of these compounds than in the case of the saltbush, but it is a matter of common experience and knowledge that sheep thrive on the beet tops. If analogy holds in the case, we are justified in adopting the proposition that the loss is probably not due to the inorganic matter digested.

§123. Returning to our comparison of the energy relations of the alfalfa and the corn fodder, it is to be remembered that both fodders proved to be good ones. The alfalfa, however, producing a much greater gain in live weight than the corn fodder did under

the conditions of the experiment. The corn fodder, however, considering the coarseness of a large portion of it, one-third of it being stalks which the sheep ate very reluctantly, produced excellent results. I endeavored to induce the sheep to eat as much of the corn fodder as possible, so their ration was not made large enough to encourage them in selecting the most acceptable portions of the fodder. I do not know how much virtue there may be in the corn stalks, but they are certainly in no manner comparable to the stems of alfalfa, whose composition indicates that, without any leaves, they constitute a better fodder than some hays which are held in fair esteem, but sheep will not eat even these when coarse and hard.

§124. The amount of energy appropriated by the animal and the effect produced per unit of heat are the important points, especially from the standpoint of the feeder. Each gram of water free alfalfa is equivalent to 4,363 calories, 62.43 per cent. of which is available, and each gram of corn fodder is equivalent to 4,244 calories, 56 per cent. of which is available, *i. e.*, is taken up by the animal. The sheep receiving alfalfa appropriated 30,955,663 calories and those receiving corn fodder appropriated 19,424,180 calories, a difference of 11,531,483 calories. The former gained nine pounds in weight, the latter three and a half pounds, a difference of five and one-half pounds, which would indicate the consumption of 2,096,634 calories in the form of alfalfa for the production of one pound of gain in the live weight, which corresponds to very nearly two pounds of alfalfa, taking 453 grams as a pound and 62 as the percentage of heat appropriated by the sheep. The energy actually necessary to maintain the animals is considered to be the same in both cases; this is an assumption which is probably not wholly justified, neither is it shown that like amounts of energy in the corn fodder and alfalfa will produce the same results in pounds of mutton as is here tacitly assumed. The calorific value of the urine was not determined in either case, neither was the nitrogen in it determined.

§125. As already stated, the total dry matter consumed by the alfalfa fed sheep was 11,365 grams, while those receiving corn fodder consumed but 8,289. The dry matter digested was 7,046 and 4,642 grams, respectively. The coefficients of digestion found for this dry matter were 62.08 and 56.66, respectively. The percentages of the heat appropriated were very nearly the same as these coefficients, viz: 62.43 and 56.00 per cent. One would scarcely anticipate so close an agreement.

§126. The distribution of the heat values in the different extracts and the coefficients of these extracts, together with their respective amounts, show great differences between the fodders.

TABLE LXV.

	Alfalfa Extract Per cent.	Coefficient	Cornfodder Extract Per cent.	Coefficient
80% alcohol	27.50	73.88	29.61	73.79
Cold water	8.66	78.89	4.59	54.16
Hot water and malt	4.37	70.24	3.24	54.37
1% hydric chlorid	12.23	60.20	19.90	69.42
1% sodic hydrate	16.19	67.72	13.79	36.27
Chlorin	8.76	25.39	3.55	———
Residue	22.29	52.67	25.32	54.00

§127. The most patent difference here is in the case of the sodic hydrate, both in the quantity that is soluble and in the coefficient of digestion. The difference of about 2 per cent. in favor of the portion dissolved out of the alfalfa by the caustic soda is much less than the relative amounts of proteids present in the fodders; while the difference in the amount soluble is only 2 per cent., the coefficient of digestibility is more than double that of the portion dissolved out of the corn fodder.

TABLE LXVI.

THE CALORIFIC VALUE OF THE FODDERS AND THEIR RESPECTIVE EXTRACTS.

	Alfalfa	Corn Fodder
Original fodder	4363	4244
Extracts:		
Alcoholic (hot 80% alcohol)	4706	4224
Cold and hot water	3140	3009
One per cent. hydric chlorid	3596	4290
One per cent. sodic hydrate	5063	5003
Chlorin, etc.	5598	4663
Residue, cellulose	4210	4134

TABLE LXVII.

CALORIFIC VALUES OF THE FECES AND THEIR EXTRACTS.

	Alfalfa	Corn Fodder
Original	4525	4248
Extracts:		
Alcohol (hot 80% alcohol)	5739	5057
Cold and hot water	4123	2738
One per cent. hydric chlorid	4061	5069
One per cent. sodic hydrate	2997	4507
Chlorin	5842	4304
Residue, cellulose	4294	3714

TABLE LXVIII.

THE COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF ALFALFA AND CORN FODDER.

ALFALFA.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	15,852,166	5,113,449	10,738,717	67.75
Aqueous extracts*	5,074,240	1,599,724	3,474,516	68.51
1% hydric chlorid extract	5,447,940	2,448,783	2,999,157	54.75
1% sodic hydrate extract	10,156,378	1,938,059	8,218,319	80.92
Chlorin, etc., extract	6,045,840	4,708,652	1,337,188	24.03
Residue or cellulose	11,522,770	5,570,208	5,952,562	51.66

CORN FODDER

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Alcoholic extract	10,238,976	3,211,195	7,027,781	71.10
Aqueous extracts	2,337,996	848,780	1,489,213	63.69
1% hydric chlorid extract	7,691,970	2,774,812	4,914,158	63.88
1% sodic hydrate extract	6,098,657	3,952,639	2,146,018	35.17
Chlorin, etc., extract	1,482,734	1,859,328	(— 376,594)	——
Residue or cellulose	9,264,294	3,829,138	5,435,160	58.67

§128. Though the preceding table is based upon the calorific values of the extracts calculated from the values of the residues, the total differs, in the case of the alfalfa, from that obtained by using the values obtained for the hay and feces by about 5 per cent., which is a closer agreement than I had anticipated. In the case of the corn fodder, the agreement is not so good, but is, even in this case, only 9.3 per cent; the calculated values being the higher in both cases.

§129. These results show that the fodders agree in this, that the alcoholic extract and the cellulose furnish a large percentage of the total heat value appropriated by the sheep, 16,691,297 calories out of a total of 31,720,459 calories, or 51 per cent., approximately. The heat yielded by the cellulose in the two fodders is nearly the same. The hydric chlorid and sodic hydrate extracts are reversed in the two fodders; that is, the sodic hydrate extract shows a very much higher value in the alfalfa and a very much lower one in the corn fodder than the hydric chlorid extract, yielding almost three times as much heat in the case of alfalfa and less than half as much in that of the corn fodder. The high proteid content of the alfalfa may correspond to the higher heat value of the sodic hydrate extract, but the distribution of the nitrogen among the extracts does not lend much probability to this idea, for the sodic hydrate solu-

*Aqueous extract includes all that was dissolved out by successive treatment with cold water, boiling with water for one hour and subsequent digestion with malt extract.

tion dissolves only about one-half of the nitrogen contained in the alfalfa, the other half being contained in the alcoholic extract (7-19) and in the hydric chlorid extract (1-10). The relative amounts of heat appropriated by the animals from these two extracts is remarkably different, 80.9 per cent. of that from the alfalfa being appropriated, while only 35.17 per cent. of that from the corn stalks. In the alfalfa the three portions, *i. e.*, extracts obtained by treatment with alcohol, and sodic hydrate and the residue, or that portion which we have called cellulose, yield five-sixths of the available heat; in the corn fodder it is the extracts removed by alcohol, hydric chlorid and the residue or cellulose that furnish almost six-sevenths of the total heat.

§130. These two fodders agree in showing that the alcoholic extract and the cellulose are two important factors in a fodder; they differ in regard to the third factor, one indicating that the portion soluble in sodic hydrate and the other that that soluble in hydric chlorid, is the third in importance. This is probably the big difference between the two, though both are capable of furnishing more energy than is necessary to simply maintain the animal and contain no constituent whose physiological action is detrimental.

§131. There are many hints that the results are modified to a considerable extent by the fecal matter proper, but it is not separable from the undigested residue of the fodder.

§132. The difference between the sodic hydrate extracts in these two cases is great, not only in the quantity of heat represented, but also in the availability of the heat value of the substances taken into solution. The sheep consumed, in round numbers, ten millions heat units with the alfalfa which had proven insoluble in the alcohol, water and hydric chlorid, of which 80.92 per cent. were available, while the others consumed but six millions from the corn fodder, of which only 35.17 per cent. were available, making an actual difference of over six millions of heat units obtained from this portion of these fodders. These quantities are those actually consumed and appropriated by the sheep and not comparisons based on like weights of the fodders. Such a comparison would result in a more favorable showing for the corn fodder.

§133. The distribution of the nitrogenous substances in the various extracts of alfalfa hay have been given in a previous table and also that for the corn fodder. The big feature in the case of the alfalfa is that nearly 50 per cent. of the total digestible nitrogenous substances is insoluble in alcohol water and hydric chlorid but soluble in sodic hydrate and, further, that 80.89 per cent. of the total, soluble in sodic hydrate, is digestible. This ratio holds, too, for native hay, but the coefficient of digestion for the nitrogenous mat-

ters soluble under these conditions is but 58.63 per cent. In the corn fodder we have an entirely different distribution of the proteids among the various extracts, over two thirds of the total digestible nitrogenous substances being soluble in boiling eighty per cent. alcohol and nearly one-half of the nitrogen consumed is soluble in the same menstruum. The large amount of nitrogen, calculated as proteids, in the feces, soluble in sodic hydrate, points clearly, as I interpret it, to the presence of nitrogenous fecal matter, even in excess of the total amount, soluble in this reagent, present in the fodder consumed. This is the most marked instance, so far met with, indicative of the disturbing influence of fecal matter upon the results of our work, but it is not the only one. It seems to be almost a rule that the nitrogen removable by treatment with chlorin, sodic hydrate and sulfurous acid is greater in the feces than in the fodder consumed, though in this particular case it is less. The amount of nitrogen involved in this portion, nitrogen removable by treatment with chlorin, etc., as well as that contained in the final residue, designated cellulose, and also in the portion removed by successive treatment with cold water, hot water and malt, is quite small and, for this reason, of little importance. Their frequent excess in the feces points to the influence of the presence of fecal matter, which differs in the case of different fodders.

§134. The results of the study of the distribution of the nitrogen in the respective extracts, as well as the distribution of the heat values of the extracts, indicate that the greatest differences between these two fodders is in the character of the two extracts obtained by hydric chlorid and sodic hydrate. In studying the results, it is to be borne in mind that there are actually a larger edible ration fed in the case of the alfalfa than in that of the corn fodder, because, as before stated, I tried to induce the sheep to consume the largest possible portion of the corn fodder fed. I am quite convinced that I would have obtained results more favorable to the corn fodder had I fed them from one-third to one-half more of it and thus made it possible for the sheep to select the portions which they liked to a greater extent than they did. There was eaten 11,365 grams of dry matter as alfalfa, and but 8,289 grams as corn fodder. In order to have induced the sheep to eat the same amount of corn fodder as they actually did eat of alfalfa, it would probably have been necessary to increase the ration by one-half. I have so far purposely avoided comparing these fodders weight for weight. It may be well to do so, but very briefly. The three sheep appropriated 19,424,180 calories from the 8,289 grams of corn fodder consumed, or 2,344 calories per gram, while a like number of sheep appropriated 30,955,663 calories from 11,365 grams of alfalfa, or 2,736 calories per

gram, which shows a difference in favor of the alfalfa of only 392 calories per gram of fodder eaten.

SORGHUM FODDER.

§135. This fodder was grown in the extreme eastern part of the State without irrigation. It was cut when a few canes were far enough advanced to mature the seed in shock. The fodder stood in shock till the latter part of the winter, but was not fed till the latter part of the spring. The variety was Minnesota Early Amber.

The following is the analytical data:

TABLE LXIX.

FODDER ANALYSIS.

SORGHUM FODDER.		CORRESPONDING FECES.	
		Sheep No. 1.	
Moisture	5.75	Moisture	6.80
Ash	8.17	Ash	11.46
Ether extract	1.55	Ether extract	1.28
Proteids	5.80	Proteids	8.48
Crude fibre	23.26	Crude fibre	28.16
Nitrogen-free extract	55.47	Nitrogen-free extract	43.82
	100.00		100.00

TABLE LXX.

ASH ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Percentage of ash in fodder	8.77	Percentage of ash in feces	11.46
Carbon	0.000	Carbon	0.000
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.120
Ignition	(1.260)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen-Chlorin	1.546	Oxygen-Chlorin	0.355
	100.000		100.000

TABLE LXXI.

ULTIMATE ANALYSIS.

SORGHUM.		CORRESPONDING FECES.	
Carbon	42.402	Carbon	43.926
Hydrogen	5.748	Hydrogen	5.826
Nitrogen	0.928	Nitrogen	1.362
Sulfur	0.085	Sulfur	0.115
Chlorin	0.553	Chlorin	0.305
Ash and oxygen	50.284	Ash and oxygen	48.466
	100.000		100.000

§136. The average coefficients of digestion found for this fodder were as follows: Dry matter, 58.46; ash, 44.61; fat, 64.87; proteids, 43.06; crude fibre, 49.23; nitrogen-free extract, 61.06. The three animals to which this fodder was fed lost eight and one-half pounds in five days and consumed 30 to 31 pounds of dry matter per thousand weight of animal. The fodder was evidently acceptable to the animals, but the results were unfavorable.

TABLE LXXII.

PROXIMATE ANALYSIS.

SORGHUM FODDER.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	35.492	35.727	35.60
Cold water, 24 hours, extracted	3.966	4.065	4.02
Hot water extracted	7.634	7.468	7.55
Hydric chlorid 1% sol. extracted	18.955	17.480	18.22
Sodic hydrate 1% sol. extracted	11.048	11.982	11.52
Chlorin, etc., extracted	4.327	4.579	4.45
Cellulose	18.578	18.699	18.64
SUGARS IN THE EXTRACTS.			
Glucose in alcoholic extract	9.31	9.46	9.39
Sucrose in alcoholic extract	6.80	7.22	7.01
Gums in cold water extract	0.36	0.32	0.34
Starch in hot water extract	2.45	2.52	2.49
Xylan in hydric chlorid extract	13.59	13.78	13.68
Xylan in sodic hydrate extract	0.66	0.68	0.67

TABLE LXXIII.

PROXIMATE ANALYSIS.

SORGHUM ORTS.	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted	41.809	42.624	42.21
Cold water in 24 hrs. extracted	2.960	3.040	3.00
Hot water extracted	2.581	2.400	2.49
Hydric chlorid 1% sol. extracted	17.499	17.412	17.46
Sodic hydrate 1% sol. extracted	12.474	12.727	12.60
Chlorin, etc., extracted	3.066	3.114	3.09
Cellulose	19.611	18.683	19.15

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	Lost	14.95	14.95
Sucrose in alcoholic extract.....	Lost	10.73	10.73
Gums in cold water extract.....	0.59	0.46	0.53
Starch in hot water extract.....	1.18	1.05	1.12
Xylan in hydric chlorid extract.....	14.94	15.51	15.23
Xylan in sodic hydrate extract.....	0.80	0.82	.81

TABLE LXXIV.

FECES OF SHEEP FED ON SORGHUM.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	15.180	14.986	15.08
Cold water in 24 hrs. extracted.....	3.728	3.669	3.70
Hot water extracted	4.190	5.005	4.60
Hydric chlorid 1% sol. extracted.....	22.481	22.205	22.34
Sodic hydrate 1% sol. extracted.....	20.461	20.270	20.37
Chlorin, etc., extracted	11.172	10.039	10.61
Cellulose	22.788	23.826	23.30
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	None	None	None
Gums in cold water extract.....	0.20	0.20	0.20
Starch in hot water extract.....	0.36	0.39	0.38
Xylan in hydric chlorid extract.....	13.45	13.14	13.30
Xylan in sodic hydrate extract.....	1.11	1.11	1.11

TABLE LXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract..	4742.9	738.1	4004.8	731.3	3273.5	81.74
Total cold water extract.	535.6	52.5	483.1	179.4	303.7	62.86
Total hot water extract.	1005.9	43.6	962.3	223.1	739.2	76.82
Total hydric chlorid ext.	2427.5	305.3	2122.2	1083.3	1038.9	48.95
Total sodic hydrate ext..	1534.8	220.3	1314.5	987.8	326.7	24.85
Total chlorin, etc., ext...	592.9	54.0	538.9	514.5	24.4	4.53
Residue, cellulose	2483.4	334.9	2148.5	1129.9	1018.6	47.41
	13323.0	1748.7	11574.3	4849.3	6725.0	58.10

§137. The coefficients for the dry matter obtained with the three sheep were as follows: 57.53, 58.22 and 59.63; average 58.46 per cent.

TABLE LXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES CONTAINED IN SORGHUM FODDDER.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcoholic ext...	1251.0	261.4	989.6	0.0	989.6	100.00
Sucrose in alcohol extract.	934.0	187.6	746.4	0.0	746.4	100.00
Gums in cold water ext...	45.3	9.3	36.0	9.7	26.3	73.06
Starch in hot water ext...	331.7	19.6	312.1	18.4	293.7	94.11
Xylan in hydric chlorid ext	1822.6	266.3	1556.3	645.0	911.3	58.56
Xylan in sodic hydrate ext	89.3	14.2	75.1	53.8	21.3	28.26
	4473.9	758.4	3715.5	726.9	2988.6	80.43

TABLE LXXVII.

FURFUROL FOUND IN SORGHUM FODDER AND IN THE CORRESPONDING ORTS AND FECES.

	Sorghum Per cent.	Orts Per cent.	Feces Per cent.
Original	9.680	10.069	12.530
Residue after treatment with 80% alcohol...	9.410	9.856	12.016
Residue after treatment with cold water....	Same	Same	Same
Residue after treatment with hot water and malt	8.638	Same	11.628
Residue after treatment with hydric chlorid	3.322	4.626	4.662
Residue after treatment with sodic hydrate.	1.957	2.387	2.456
Residue after treatment with chlorin, etc....	1.746	1.641	Not det

TABLE LXXVIII.

COEFFICIENTS OF DIGESTION FOR FURFUROL IN SORGHUM AND IN THE PORTIONS DISSOLVED OUT BY THE VARIOUS SOLVENTS USED.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Sorghum	1290.5	176.1	1114.4	6076.	506.8	45.48
Soluble in 80% alcohol ...	36.0	3.7	32.3	24.9	7.4	22.91
Soluble in cold and hot water	10.3	5.4	4.9	18.8	(—13.9)	.....
Soluble in 1% hydric chlorid	708.3	86.0	622.3	337.8	284.5	45.72
Sol. in 1% sodic hydrate...	182.7	39.2	143.5	107.0	36.5	25.44
Soluble in chlorin, etc....	27.3	13.0	14.3	111.9	106.3	48.72
Remaining in the cellulose	232.6	28.7	203.9			
			1120.9	600.4	520.9	46.46

METHOXYL GROUP.

§138. The amount of this group found in the fodder was 1.027 per cent.; in the feces, 3.379 per cent. No determination of this group was made with the orts. The result shows an excess of 45 grams in the feces, which is due either to some mistake in the

determination or indicates the probable presence of this group in fecal matter. The results of our determinations, 14 in all, indicate a much higher percentage of this group in the feces than in the fodder consumed. The results in this case are very high for the feces, but it was done in triplicate and the three determinations agree very well.

AMID NITROGEN.

§139. The amount of amid nitrogen found in the sorghum was small, corresponding to only 0.884 per cent. calculated as proteids. We found none or only a trace in the orts and 1.168 per cent. in the feces. The coefficient of digestion found in this case was 51.91 per cent. This is somewhat higher than the coefficient found for the total nitrogen calculated as proteids, 8.95 per cent. higher.

HEAT APPROPRIATED BY THE ANIMALS.

§140. The air-dried fodder possessed a heat value of 3,890 calories per gram; the orts, 1,749 grams in weight, are supposed to have the same value; the feces, which weighed 4,849 grams, had a fuel value of 4,111 calories per gram. The sheep consumed 11,574 grams of air-dried fodder and appropriated 55.72 per cent. of its fuel value.

§141. We did not determine the distribution of the proteids in the various extracts of sorghum and their respective coefficients of digestion, neither did we make a detailed study of the fuel values of the respective extracts, etc.

§142. This fodder had already proved to be a disappointment, but not to as great an extent as the saltbush, so I scarcely hoped to gain anything by extending this work.

§143. The sheep fed on this fodder lost in the five days between the two weighings, 3, 2½ and 3 pounds, respectively, an aggregate loss of 8½ pounds. They appropriated in this period 25,088,621 calories, which was evidently not sufficient to maintain the animals in good condition. The coefficients of digestion for this fodder were quite as promising as those obtained for corn fodder, with the exception of that obtained for the crude fibre; the latter coefficient is nearly 8 per cent lower in the sorghum than in the cornfodder. The dry matter consumed by the sheep when fed corn fodder was 8,289 and 10,934 when fed sorghum; the same sheep were used in these two experiments and the conditions were equally favorable in both series. The sheep all gained on the corn fodder and lost while being fed the sorghum fodder. The sheep appropriated 19,424,180 calories while feeding on corn fodder, as against 25,088,621 while feeding on sorghum. The urine was unfortunately not collected

and analyzed. The water drank while feeding on corn fodder weighed 27½ pounds, and as the weather was cold, the water was warmed to about 22° C. before it was offered to the sheep. The weight of water consumed while feeding on sorghum was 60½ pounds and was not warmed, as the temperature of the water was at this time about 15° C. The daily consumption of water was a trifle over twice as much per sheep while feeding or sorghum as while feeding on corn fodder. In the former case, it was four pounds, and in the latter nearly two pounds per sheep. This amount of water, 4 pounds, is probably not excessive, as the sheep fed on alfalfa drank almost 4¾ pounds daily and made a gain of about three pounds each in the five days, but they did appropriate nearly 6,000,000 more calories than the sheep feeding on sorghum. The three sheep used in the experiment with the alfalfa were not the same three used in the sorghum experiment, but each of the sheep used in the alfalfa experiment gained about three pounds in five days, and each of those used in the sorghum lost about three pounds in five days.

§144. It is evident from the context that the gain and loss is in terms of live weight, this being the only kind of gain or loss considered in this bulletin.

SALTBUSH, *Atriplex argentea.*

§145. This plant is used to some extent in the eastern part of this state in making a hay to feed during heavy storms when the stock cannot otherwise obtain forage enough to sustain themselves. I undertook the study of this plant in the hope that it might prove worthy of commendation as a fodder, as some of the Australian saltbushes have proved to be. The uncertainty of raising crops in the eastern portions of the state make it desirable to find some plant which will serve the purpose of a good forage and which will grow sufficiently well under the prevailing conditions to produce a fair crop. The people most directly concerned in this have used this native plant; therefore, I undertook its examination.

§146. Its effects upon the sheep, three in number, were not injurious. They seemed to suffer no inconvenience except that they drank a large quantity of water and voided an excessive amount of urine, which had an offensive odor. They otherwise appeared healthy. They ate freely of this hay and chewed their cuds contentedly. If I had made a second experiment and not allowed them to drink so much water, more favorable results might have been obtained.

TABLE LXXIX.

ANALYTICAL DATA FOR THE SALTBUSH, *Atriplex argentea.*

FODDER ANALYSIS.

SALTBUSH.		CORRESPONDING FECES. Sheep No. 4.	
Moisture	5.32	Moisture	6.53
Ash	19.28	Ash	10.53
Ether extract	1.46	Ether extract	1.32
Proteids	9.73	Proteids	6.27
Crude fibre	27.33	Crude fibre	40.44
Nitrogen-free extract	36.88	Nitrogen-free extract	34.91
	100.00		100.00

TABLE LXXX.

ANALYSIS OF THE ASHES.

SALTBUSH.		CORRESPONDING FECES.	
Carbon		Carbon	
Sand	30.097	Sand	43.025
Silicic acid	7.220	Silicic acid	18.718
Sulfuric acid	1.893	Sulfuric acid	0.963
Phosphoric acid	2.838	Phosphoric acid	5.963
Carbonic acid	10.395	Carbonic acid	0.846
Chlorin	6.859	Chlorin	1.576
Potassic oxid	30.980	Potassic oxid	7.944
Sodic oxid	0.073	Sodic oxid	1.316
Calcic oxid	4.730	Calcic oxid	7.548
Magnesic oxid	3.588	Magnesic oxid	6.353
Ferric oxid	0.970	Ferric oxid	1.080
Aluminic oxid	0.443	Aluminic oxid	1.026
Manganic oxid	0.200	Manganic oxid	0.140
Ignition	(1.26)	Ignition	(3.877)
Sum	101.546	Sum	100.355
Oxygen equivalent to chlorin	1.546	Oxygen equivalent to chlorin	.355
	100.000		100.000

ANALYSIS OF THE ASH.

TABLE LXXXI.

ULTIMATE ANALYSIS.

SALTBUSH. Atriplex argentea.		CORRESPONDING FECES.	
Carbon	41.370	Carbon	44.700
Hydrogen	5.581	Hydrogen	5.961
Nitrogen	1.557	Nitrogen	1.003
Sulfur	0.320	Sulfur	0.205
Chlorin	3.965	Chlorin	0.234
Ash	19.280	Ash	10.530
Oxygen (approx.)	27.927	Oxygen (approx.)	37.367
	100.000		100.000

§147. The sulfur and chlorin determinations were made on samples of the fodder, as in previous instances, and not calculated from the ash.

TABLE LXXXII.

SALTBUSH, *Atriplex argentea.*

PROXIMATE ANALYSIS.

	I	II	Av.
	Per cent.	Per cent.	Per cent.
Eighty per cent. alcohol extracted....	22.243	21.877	22.06
Cold water in 24 hrs. extracted.....	6.777	7.101	6.94
Hot water extracted	5.762	5.852	5.81
Hydric chlorid 1% sol. extracted.....	19.214	19.719	19.46
Sodic hydrate 1% sol. extracted.....	15.734	17.686	16.71
Chlorin, etc., extracted	10.803	9.762	10.28
Cellulose	19.467	18.003	18.74
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	0.88	0.63	0.76
Sucrose in alcoholic extract.....	1.28	1.23	1.25
Gums in cold water extract.....	0.57	0.57	0.57
Starch in hot water extract.....	1.45	1.45	1.45
Xylan in hydric chlorid extract.....	7.48	7.62	7.55
Xylan in sodic hydrate extract.....	2.11	1.67	1.89

TABLE LXXXIII.

SALTBUSH ORTS.

PROXIMATE ANALYSIS.

	I	II	Av.
	Per cent.	Per cent.	Per cent.
Eighty per cent. alcohol extracted....	21.537	21.391	21.47
Cold water in 24 hrs. extracted.....	6.548	6.317	6.43
Hot water extracted	3.239	3.685	3.46
Hydric chlorid 1% sol. extracted.....	17.301	17.450	17.38
Sodic hydrate 1% sol. extracted.....	17.152	17.289	17.22
Chlorin, etc., extracted	11.856	11.857	11.86
Cellulose	22.367	22.011	22.18
			100.00

SUGARS IN THE EXTRACTS.

Glucose in alcoholic extract.....	0.61	0.50	0.56
Sucrose in alcoholic extract.....	1.10	1.13	1.12
Gums in cold water extract.....	0.92	0.70	0.81
Starch in hot water extract.....	1.25	1.18	1.22
Xylan in hydric chlorid extract.....	7.29	7.40	7.35
Xylan in sodic hydrate extract.....	2.37	2.46	2.42

TABLE LXXXIV.

FECES OF SHEEP FED ON SALTBUSH.

PROXIMATE ANALYSIS.

	I Per cent.	II Per cent.	Av. Per cent.
Eighty per cent. alcohol extracted....	12.802	11.295	12.05
Cold water in 24 hrs. extracted.....	3.248	3.719	3.48
Hot water extracted	3.050	3.023	3.04
Hydric chlorid 1% sol. extracted.....	21.700	22.315	22.00
Sodic hydrate 1% sol. extracted.....	16.902	20.464	18.68
Chlorin, etc., extracted	18.932	15.319	17.13
Cellulose	23.366	23.865	23.62
			100.00
SUGARS IN THE EXTRACTS.			
Glucose in alcoholic extract.....	None	None	None
Sucrose in alcoholic extract.....	0.21	0.21	0.21
Gums in cold water extract.....	0.38	0.38	0.38
Starch in hot water extract.....	None	None	None
Xylan in hydric chlorid extract.....	5.03	6.55	5.79
Xylan in sodic hydrate extract.....	4.15	3.47	3.81

TABLE LXXXV.

COEFFICIENTS OF DIGESTION FOR THE VARIOUS EXTRACTS OF SALTBUSH, *Atriplex Argentea.*

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Total alcoholic extract...	4250.1	682.6	3567.5	1052.8	2514.7	70.49
Total cold water extract..	1337.1	204.4	1132.7	304.1	828.6	73.15
Total hot water and malt extract	1119.4	109.0	1010.4	265.6	744.8	73.54
Total hydric chlorid ext..	3749.2	552.7	3196.5	1922.1	1274.4	39.87
Total sodic hydrate extract	3219.3	547.3	2672.0	1632.0	1040.0	49.00
Total chlorin, etc., extract	1980.6	376.9	1603.7	1496.6	107.1	6.28
Total residue, cellulose ...	3610.5	705.2	2905.3	2063.6	841.7	28.97
	19266.2	3178.1	16088.1	8736.8	7351.3	45.70

The general coefficients obtained for the digestibility of the dry matter were 46.40, 45.84 and 46.50, with the individual sheep; average, 46.25 per cent.

TABLE LXXXVI.

COEFFICIENTS OF DIGESTION FOR THE CARBOHYDRATES IN THE SALTBUSH, *Atriplex Argentea.*

(As indicated by the sugars obtained from the various extracts.)

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Glucose in alcohol extract	146.4	17.8	128.6	0.0	128.6	100.00
Sucrose in alcohol extract	240.3	35.6	204.7	14.6	190.1	92.87
Gums in cold water ext...	109.8	25.7	84.1	32.2	51.9	61.71
Starch in hot water and malt extract	279.4	38.8	240.6	0.0	240.6	100.00
Xylan in hydric chlorid ext	1454.6	233.6	1221.0	505.9	715.1	58.57
Xylan(?) in sodic hydrate extract	364.1	76.9	287.2	332.9	(—45.7)	——

TABLE LXXXVII.

FURFUROL FOUND IN SALTBUSH, *Atriplex argentea*, AND IN THE CORRESPONDING ORTS AND FECES.

	Saltbush Per cent.	Orts Per cent.	Feces Per cent.
Original	9.642	10.488	10.926
Residue after treatment with 80% alcohol	9.642	10.363	10.926
Residue after treatment with cold water	9.058	Same	Same
Residue after treatment with hot water and malt	7.608	10.140	10.440
Residue after treatment with hydric chlorid	4.708	6.036	5.298
Residue after treatment with sodic hydrate	2.570	2.985	3.364
Residue after treatment with chlorin, etc	2.042	1.216	Not det

TABLE LXXXVIII.

COEFFICIENTS OF DIGESTION FOUND FOR FURFUROL IN THE SALTBUSH, *Atriplex argentea*.

	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Furfurol in Saltbush	1857.6	333.2	1524.4	954.6	569.8	37.38
Furfurol soluble in 80% alcohol	0.0	0.0	0.0	0.0	0.0	———
Furfurol soluble in water and malt	391.9	9.6	382.3	42.1	340.2	88.99
Furfurol soluble in 1% hydric chlorid	558.7	130.4	428.3	449.6	(—21.3)	———
Furfurol soluble in 1% sodic hydrate	412.0	97.0	315.0	169.0	146.0	46.35
Furfurol soluble in chlorin, etc.	101.7	56.2	45.5	293.9	106.4	26.49
Furfurol remaining in the residue	393.4	38.6	354.8			
			1525.9	954.6	571.3	37.37

TABLE LXXXIX.

COEFFICIENTS OF DIGESTION FOR THE PROTEIDS IN THE VARIOUS EXTRACTS OF THE SALTBUSH, *Atriplex argentea*.

Solvent.	Fed.	Orts.	Consumed.	Voided.	Digested.	Coef.
Boiling 80% alcohol	691.7	62.3	629.4	76.1	553.3	87.91
Cold water	57.0	26.7	30.3	45.4	(—15.1)	———
Hot water and malt	108.4	6.7	101.7	37.1	64.6	63.52
1% hydric chlorid	133.1	27.8	105.3	59.4	45.8	43.50
1% sodic hydrate,	618.4	79.5	538.9	161.3	377.6	70.10
Chlorin, sodic hydrate and sulfurous acid	236.4	18.4	218.0	154.5	63.5	29.13
Remaining in cellulose	—29.3	6.8	22.5	22.4	00.1	0.00
	1874.3	228.2	1646.1	556.3	1098.8	66.21

§148. The coefficients of digestion found for the proteids with the three sheep were 67.56, 64.69 and 66.83. The average is 66.36. Bulletin 93, page 38.

METHOXYL GROUP IN THE SALTBUSH, *Atriplex argentea.*

§149. The saltbush hay was examined for the presence of this substance in the same manner that the other fodders were examined. The amount found was 2.104 per cent. I assume that the difference in the amount of this group present in the orts and in the hay is so small that no serious error is made in considering them the same, and I, therefore, made no attempt to determine this group in the orts. The amount in the feces is 2.929 per cent. The total weight of this group consumed was 338.49 grams; the amount voided was 255.90 grams; the amount digested was 82.6 grams, or 24.40 per cent.

§150. Alfalfa, timothy, native hay, corn fodder and the saltbush agree in showing that the substances containing this group are broken down to the extent of about 25 per cent. of the amount present. The result obtained with sorghum was wholly unsatisfactory; though the determination of this group in the feces, corresponding to the sorghum, was made three times and in the sorghum itself twice, with satisfactory agreement in every case. The result, however, indicates that fecal matter may yield this group or, perhaps, it is safer to interpret it that the substances containing this group in the case of sorghum are not digested at all, and that the excess of methoxyl in the feces is due to some error in our determination which we failed to detect, even though we repeated it.

AMID NITROGEN.

§151. The amid nitrogen found in the saltbush hay corresponded to 4.180 per cent of proteids, while that in the orts represented only 1.556 per cent. of proteids. We failed to find any in the feces. As we usually interpret these results, the amid nitrogen was wholly digestible, or has a coefficient of 100.00 per cent.

THE FUEL VALUE OF SALTBUSH, *Atriplex argentea.*

§152. The total dry matter consumed by the sheep in five days was 15,253 grams. We found the calorific value of this dry matter to be 3,886 calories per gram, or a total of 59,273,158 calories. The dry matter in the feces was 8,200 grams, with a heat value of 4,398 calories per gram, or a total of 36,063,600 calories. The sheep, accordingly, appropriated 23,224,811 calories, or 39.16 per cent. of the fuel value—the lowest coefficient of all the fodders used.

§153. The amount of urine voided in this instance was so ex-

ceptionally large that it certainly ought to have been collected, weighed and examined, at least the nitrogen determined. The animals' systems were certainly flooded by the large amount of water drank, 196 pounds in five days, which is a little more than three times as much as the same sheep drank when fed on alfalfa hay and over four times as much as when fed on timothy hay. The heat required to raise this quantity of water from the temperature at which it was drank, 14.5° C., to the the body temperature, taken as 101° F., would be 2,014,387 calories. So large a factor as this must have considerable influence upon the effects produced by the fodder, aside from the lively diffusion induced by the presence of an unusual quantity of water in the system.

TABLE XC.

The dry saltbush hay had the following approximate composition:

Solvent.	Per cent.
Boiling 80% alcohol	17.681
Cold water, 24 hours digestion	7.329
Hot water and malt extract	6.133
One per cent. hydric chlorid	20.560
One per cent. sodic hydrate	17.649
Chlorin, sodic hydrate and sulfurous acid	10.860
Residue, cellulose	19.788
	100.000

TABLE XCI.

THE FUEL VALUES OF THE SALTBUSH HAY AND THE RESPECTIVE RESIDUES.

Dry Saltbush, Atriplex argentea hay	3886 calories
The residue after extraction with 80% alcohol	3986 calories
The residue after extraction with cold water	4284 calories
The residue after extraction with hot water and malt	4346 calories
The residue after extraction with 1% hydric chlorid	4854 calories
The residue after extraction with 1% sodic hydrate	4712 calories
The residue after extraction with chlorin, etc.	4458 calories

TABLE XCII.

THE HEAT UNITS REMOVED FROM ONE GRAM OF SALTBUSH HAY BY THE VARIOUS SOLVENTS.

Boiling 80% alcohol	565 calories
Cold water, 24 hours digestion	108 calories
Hot water and malt extract	220 calories
One per cent. hydric chlorid	649 calories
One per cent. sodic hydrate	900 calories
Chlorin, sodic hydrate and sulfurous acid	558 calories
The residue, or cellulose	886 calories
	3886 calories

TABLE XCIII.

THE FUEL VALUES OF THE RESPECTIVE EXTRACTS OF THE SALT-BUSH, *Atriplex argentea.*

One gram of the alcoholic extract	3196 calories
One gram of the cold water extract	1474 calories
One gram of the hot water and malt extract	3587 calories
One gram of the hydric chlorid extract	3157 calories
One gram of the sodic hydrate extract	5099 calories
One gram of the chlorin, etc., extract	5138 calories
One gram of the residue, cellulose	4458 calories

TABLE XCIV.

THE DRY FECES GAVE THE FOLLOWING EXTRACTS AND RESIDUE.

Solvent.	Per cent. Dissolved.
Boiling 80% alcohol	6.278
Cold water, 24 hours digestion	3.711
Hot water and malt extract	3.235
One per cent. hydric chlorid	23.452
One per cent. sodic hydrate	19.909
Chlorin, sodic hydrate and sulfurous acid	18.249
Residue, cellulose	25.166
	100.000

TABLE XCV.

THE FUEL VALUES OF THE DRY FECES (*Atriplex argentea*) AND THE RESPECTIVE RESIDUES PER GRAM.

The dry feces	4398 calories
The residue after extraction with 80% alcohol	4323 calories
The residue after extraction with cold water	4334 calories
The residue after extraction with hot water and malt	4379 calories
The residue after extraction with 1% hydric chlorid	4371 calories
The residue after extraction with 1% sodic hydrate	4801 calories
The residue after extraction with chlorin, etc., cellulose	4398 calories

TABLE XCVI.

THE HEAT UNITS REMOVED FROM ONE GRAM OF FECES BY SUCCESSIVE TREATMENT WITH THE RESPECTIVE SOLVENTS.

Boiling 80% alcohol	346 calories
Cold water, 24 hours digestion	151 calories
Hot water and malt extract	101 calories
One per cent. hydric chlorid	715 calories
One per cent. sodic hydrate	1002 calories
Chlorin, sodic hydrate and sulfurous acid	976 calories
Remaining in the residue or cellulose	1107 calories

TABLE XCVII.

THE FUEL VALUE OF THE RESPECTIVE EXTRACTS OF THE FECES PER GRAM.

Alcoholic extract	5510 calories
Cold water extract	4069 calories
Hot water extract	3122 calories
One per cent. hydric chlorid extract	3049 calories
One per cent. sodic hydrate extract	5033 calories
Chlorin, sodic hydrate and sulfurous acid extract	5347 calories
The residue or cellulose	4398 calories

TABLE XCVIII.

COEFFICIENTS OF DIGESTION FOR THE HEAT VALUES OF THE VARIOUS EXTRACTS OF THE SALTBUSH (*Atriplex argentea*) HAY.

	Heat units Consumed	Heat units Voided	Heat units Appropriated	Coef.
Eighty per cent. alcohol extract	8,619,612	2,837,650	5,781,962	67.07
Cold water extract	1,647,934	1,236,976	410,956	24.94
Hot water and malt extract	3,357,432	827,330	2,530,102	75.37
1% hydric chlorid extract	9,900,352	5,863,227	4,037,125	40.78
1% sodic hydrate extract	13,721,409	8,218,889	5,502,520	40.09
Chlorin, sodic hydrate and sulfurous acid extract	8,508,528	7,999,112	509,416	5.99
The residue or cellulose	13,449,786	9,077,472	4,372,314	32.51
	59,205,051	36,060,656	23,149.533	39.12

§154. The coefficient obtained by using the composite samples of the hay and feces was 39.16 per cent., the same as we here obtain by calculation from the values obtained for the various extracts and the analysis of the fodder.

§155. The ordinary fodder analysis indicates no reason why this saltbush hay should not be, at least, a fairly good fodder. There is present more crude proteids than in the average hay, as much nitrogen-free extract as in alfalfa hay and less crude fibre than in alfalfa hay, timothy hay, native hay or corn fodder. The only abnormally abundant constituent is the ash, which amounts to nearly one-fifth of the weight of the dry hay, but three-tenths of this is sand. This amount though large is less than is found in the dried leaves of the sugar beet which are fed with excellent results, to both cattle and sheep. The percentage of ash in the dried beet leaves, not including the crown, ranges from 23 to 27 and to even more than 30 per cent. in the leaves of fodder beets. In this saltbush the ash was found to be 19.28 per cent., somewhat less than the amount found in our sugar beet leaves. The analysis of this ash shows less chlorin, sulfuric acid and soda than the ash of the beet leaves and no more soda than the alfalfa ash. The results of the feeding experiment were, however, not favorable, as each of the three sheep lost weight, one sheep lost one-half pound, one two pounds, and the third six pounds. This loss of six pounds may have been due to the individuality of the sheep more than to the fodder, but aside from this the results in the other two cases show that the fodder is a very poor one. The coefficients of digestion obtained for these groups of food elements, *i. e.*, the ash, proteids, crude fibre and nitrogen-free extract, show some extreme differerences, *i. e.*, the coefficient of digestion for the crude fibre as shown by the three sheep was 6.02, 15.35 and 3.49 respectively, and the sheep with which we obtained a coefficient of 15.35 per cent. was the

one that lost the most, six pounds in five days. The crude proteids, on the other hand, show the highest coefficients of digestion obtained except for the proteids contained in the alfalfa. The total proteids digested by the three sheep fed on alfalfa hay with a gain of nine pounds was 1325 grams, the proteids digested by the sheep fed on the saltbush hay with a total loss of eight and one-half pounds, was 1090 grams, a difference of 235 grams in the weight of the proteids digested. The coefficient obtained for the nitrogen-free extract was very low, 49.16, whereas it was practically 73 in the case of the alfalfa whose nitrogen-free extract has a very high coefficient of digestion. The percentage of the nitrogen-free extract present in the hay is about the same as in alfalfa hay; that for the crude fibre is somewhat lower than in the other fodders forming the subjects of this study, but the percentage of ash is decidedly higher than even the alfalfa and has a very high coefficient of digestion, 71.55, against 57.67 for the alfalfa ash. The high percentage of ash found for the saltbush hay is partly due to the presence of a great deal of sand amounting to 30 per cent. of the ash. The high coefficient of digestion for the ash is fully accounted for by the fact that the base occurring in the largest quantity is potash, making over 75 per cent. of the bases present. The potash is very largely absorbed by the system while lime and magnesia are absorbed by the system in small quantities and these make up the rest of the bases. It is to be noted that in this saltbush so good as no soda salts are present in its ash, only 0.073 per cent. sodic oxid. I have already made mention of the fact that this fodder caused the animals to drink very freely, as much as 15 pounds of water a day, which is very much more than they drank when fed on other fodders, ten times as much as the minimum that the same sheep drank when fed on timothy hay and twice as much as the maximum when fed on alfalfa hay.

§156. If we take up what I have designated as the proximate analysis of this saltbush, *i. e.*, the relative amounts dissolved out of the fodder by treating it successively with 80 per cent. alcohol, etc., we find that it is quite unlike the other fodders, but approaches most nearly to timothy hay, from which it differs in two respects, *i. e.*, in having somewhat less cellulose and in the amount of material removed by chlorin which is much larger than in the case of timothy or any of the other fodders.

§157. This timothy hay proved to be a poor fodder, each of the sheep losing flesh while receiving it as an exclusive ration. The results with the saltbush were very uneven, one sheep lost but one-half pound in the five days, another lost six pounds. I take it that the saltbush was really bad for the latter sheep, though it ate the hay freely and digested a little more dry matter than the sheep that

lost only one-half pound. The difference in the loss cannot be attributed to this sheep's having drunk more water than the other, for it drank less by a few pounds, so that the disturbing influence of an excessive amount of water would probably not be greater in the one case than in the other.

§158. The portion removed from the fodders by treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid, is usually small, but amounts to 10.28 per cent. in the saltbush. The coefficient of digestion found for this portion is always low. In this case it was found to be only 6.28 per cent. The low coefficient for this portion may be more apparent than real. The percentage of it present in the feces is always comparatively high, in some cases exceeding the amount consumed. This may be, and probably is due to fecal matter, a large percentage of which is removable by this chlorin treatment, which of course would lower the coefficient found, even to the extent of reducing it to zero or showing, as is the case of some extracts, that there was more voided than was ingested.

§159. The sucrose determination in several of the fodders is rendered very doubtful, almost certainly erroneous, by the fact, as the investigation shows conclusively, that some of the substances which yield furfurol are taken into solution by alcohol and presumably yield a reducing sugar when the extract is inverted by heating with dilute acid. This doubt does not attach to the glucose, as this determination does not involve the inversion of the solution, unless such may have taken place during the repeated boilings with alcohol or during its evaporation, which was done on the water bath to avoid either local or general overheating.

§160. The fact that the alcoholic extract of the feces, corresponding to the saltbush, shows the presence of some substance equivalent to 0.21 per cent. of sucrose cannot be taken as conclusively showing the presence of sucrose, but merely that the extract contains some material susceptible of yielding a reducing power equal to this. In the case of corn fodder and sorghum, especially as a saccharine variety was used, the presence of some sucrose in the alcoholic extract of the fodder was to be expected, but the feces corresponding to these fodders yield no sucrose to the boiling 80 per cent. alcohol. The same doubt attaches itself to the starch determination that has been mentioned in connection with the sucrose, *i. e.*, we have depended upon boiling the fodder with water for one hour, cooling it and adding malt extract to bring the starch into solution, but we observe that this process removes enough furfurol in every case in which any starch was found to raise a question as to whether the reducing power was due to inverted starch or to a pentosan.

§161. The sugar found in the hydric chlorid extract of the saltbush and in the other fodders is probably xylose, except in alfalfa in which case the mucic acid found is very nearly equal to the sugar obtained by the Fehling solution and only a small portion can be attributed to xylose. My results with corn fodder are not satisfactory, but the four tests made agree in showing the presence of some mucic acid. In this case we know that both glucose and sucrose were present and whether their presence may have given rise to a mistake or not may be a question. Assuming that they did not, it would appear that other hexoses as well as pentoses are present in this fodder. In this event, the three fodders, alfalfa hay, corn fodder, and saltbush hay, are quite unlike and we find the coefficients of digestion for the sugars formed by the thorough inversion of the hydric chlorid extract to be 83.96, 89.22 and 58.57 respectively, which would indicate that the source of this sugar is different in the saltbush form than in the other two fodders. As already stated it is probably due to galactan in the alfalfa and possibly to both hexose and pentose groups in the corn fodder. The digestibilty of the hydric chlorid extract, that is all that this reagent dissolves out of these fodders, is nearly the same in the alfalfa and corn fodder, 60 per cent. in the former, and 63.88 per cent. in the latter, but it is only 39.88 per cent. for that of the saltbush.

§162. The furfurol has been considered as such and no attempt has been made to specify the particular source from which it was derived. The amount consumed in the different fodders varied from 1030 to 1526 grams and the coefficients of digestion found varied from 37.37 in the saltbush to 65.15 in the alfalfa. If there is any relation between the digestibilty of the furfurol and the value of the hay it is a very general one. The merits of the six fodders used in this study were as follows: Alfalfa, very decidedly the best, corn fodder and native hay standing next, timothy hay next, with the sorghum and saltbush standing far behind the others. The coefficient of digestionof the furfurol in these fodders was found to be as follows: Alfalfa, 65.15, native hay 50.97, corn fodder 47.07, timothy hay 50.13, sorghum 46.46 and saltbush 37.37 per cent. A study of the amount of furfurol removed by the successive treatments to which the hays and fodders were subjected establishes the fact that they deport themselves somewhat differently, the saltbush showing the same amount, relatively, after as before extraction with alcohol, while the other samples showed a decided loss. That extraction with cold water should remove a little furfurol would be expected, provided the material removed and susceptible of inversion is really due to gums. We, however, find that it is uniformly small, as is also the case with the hot water and malt

extract. The two reagents that remove the greater portions of the furfurol are the hydric chlorid and sodic hydrate, but the cellulose often contains as much as either of these. The distribution of the furfurol in the various extracts of alfalfa, the saltbush and corn fodder, may be restated to make clear these differences.

TABLE XCIX.

	Alfalfa Grams	Corn Fodder Grams	Saltbush Grams
Furfurol soluble in 80% alcohol	144.5	1341.4	0.0
Furfurol soluble in 1% hydric chlorid	202.4	590.3	428.0
Furfurol soluble in 1% sodic hydrate	218.2	316.3	315.0
Furfurol remaining in the cellulose	256.2	162.9	400.0*

§163. These results point to very great differences in the properties of the compounds yielding the furfurol. A further study of the different tables will be seen to indicate that the leaves and stems are very different in this respect.

§164. The coefficients of digestibility as indicated by the results obtained point to further differences. We have for the coefficients for the furfurol in the above extracts the following:

TABLE C.

	Alfalfa	Corn Fodder	Saltbush
Soluble in alcohol	96.50	94.80	0.0
Soluble in hydric chlorid	100.00	73.17	Apparently None
Soluble in sodic hydrate	27.18	31.82	46.35
Retained in the cellulose	72.62	32.57	26.49

§165. The coefficient given for the digestibility of the furfurol in the cellulose of the saltbush includes the portion removable by treatment with chlorin, etc. It will be recalled that, in the case of the saltbush, the group which we designate crude fibre has an exceedingly low coefficient of digestion, 15.35 being the highest obtained with either of the sheep.

§166. We will see later that the significance of these differences are quite important. The testimony of the scales in regard to the live weight of these animals is that the alfalfa is an excellent fodder, that the corn fodder is good and that the saltbush is a very poor one. I am fully aware of the importance attached to the nitrogenous substances present in a fodder in the theories of animal nutrition, but the results so far obtained in this experiment, as I interpret them, point clearly to the equal importance of the character of the carbohydrates in the fodder.

§167. The amount and distribution of the proteids in the fodders and their respective extracts have already been given, but we

*This includes the portion removable by chlorin in the above extracts.

bring them together for the three fodders that we have tried to study a little more fully than the others, *i. e.*, alfalfa, corn fodder and the saltbush, *Atriplex argentea.*

TABLE CI.

	Alfalfa	Coefficient of Digestion	Corn Fodder	Coefficient of Digestion	Saltbush	Coefficient of Digestion
The crude proteids consumed.	1817.15	72.92	472.82	37.74	1646.10	66.21
Soluble in 80% alcohol, consumed	594.41	81.69	215.76	65.49	629.40	87.91
Soluble in hydric chlorid, consumed	125.66	59.84	70.07	39.43	105.30	43.50
Soluble in sodic hydrate, consumed	851.70	81.89	98.98	0.00	538.90	70.10
Soluble in chlorin, etc., consumed	39.58	0.00	28.82	46.46	218.00	29.13

§168. We have here very great differences and, if we were to draw conclusions and base them upon the analytical results in regard to the quantity and digestibilty of the proteids present, we would certainly place the saltbush quite close to the alfalfa, but the results of the feeding, expressed in gain or loss of live weight, places the corn fodder far above the saltbush with a gain of 3½ pounds of flesh as against a loss of 8½ pounds or a total difference of 12 pounds live weight. It is only just to add that 6 pounds of the loss chargeable to the saltbush was made by one of the three animals, but even if this be due to the individuality, idiosyncrasy perhaps, of the animal, it suggests that the saltbush may be a bad fodder for many sheep, unless we were unfortunate in getting the one out of many among the three chosen with which it would give particularly unfavorable results. I have elsewhere referred to this possibility and have pointed out that the aggregate loss of the two, that did not lose such an exceptional weight, was 2½ pounds, while those fed on corn fodder gained 3½ pounds, so that after assuming that the third sheep receiving the saltbush was so sensitive to its action as to render this sheep wholly unfitted for use in the experiment, the results obtained with the remaining two indicate that this plant is not fitted for a forage plant. The corn fodder, so far as the proteids are concerned, is not so good as the saltbush, but if we consider the carbohydrates as indicated by the sugars obtained in the inverted solutions, or by the furfurol obtained, and their coefficients of digestion, the corn fodder would appear to be much the better of the two, and this is the fact. This view of the importance of the carbohydrates will receive some confirmation when we briefly review the energy supplied by these three fodders and their extracts.

§169. The methoxyl group occurs in all of the fodders, but it is not very abundant, and its coefficient of digestion is low.

§170. The amid nitrogen is not abundant in these hays but its coefficient of digestion is high. How much energy it may yield in its changes either absolutely or in comparison with the albumenoids, I do not know.

§171. Perhaps the most suggestive results are those obtained with the bomb calorimeter. The percentage of heat which disappears from the fodder in its passage through the animal, varies with the different fodders; for the saltbush we found that 39.16 per cent. of the energy had disappeared; for the corn fodder 56.00 per cent., and for the alfalfa 62.43 per cent. In studying the respective extracts, the results agree in showing that the alcoholic extract furnished the largest amount of heat. Next to this in the case of the alfalfa and the saltbush comes the sodic hydrate extract, but in the corn fodder, the residue or cellulose furnishes the second largest quantity. The third largest quantity is furnished in the case of the alfalfa and saltbush by the cellulose and in the corn fodder by the hydric chlorid extract, as shown by the following statement of the heat units appropriated by the sheep from the respective portions:

TABLE CII.

	Alfalfa	Corn Fodder	Saltbush
Alcoholic extract yielded	10,737,717	7,027,781	5,781,962
Sodic hydrate extract yielded	8,218,319	2,146,018	5,502,520
Hydric chlorid extract yielded	2,999,157	4,914,158	4,037,125
Residue or cellulose	5,952,562	5,435,160	4,372,314

§172. These results are quite consonant with those obtained from the study of the extracts which show that the respective fodders yielded the following quantities of digestible material in grams:

TABLE CIII.

	Alfalfa	Corn Fodder	Saltbush
Alcohol extract	2520	1789	2515
Hydric chlorid extract	912	1245	1274
Sodic hydrate extract	1359	342	1040
Residue	1442	1210	841

§173. The fuel value of these different portions are not equal and the coefficients of digestion are also unequal, so that a close agreement could not be expected. The general deportment of the timothy and native hay would seem to place them close to corn fodder. The sorghum shows a large amount of digestible alcoholic extract, hydric chlorid extract and cellulose, but less of the latter two than the corn fodder and though they seem to be large enough in quantity and fairly proportioned, the sheep lost weight amount-

ing to almost three pounds each while being fed on this sorghum fodder.

§174. The amount of residue or cellulose digested in the various trials, the comparative uniformity of the coefficient of digestion and fuel value, indicate a very considerable food value for this portion of the fodder. It is the only portion of the saltbush that was not digested in the usual quantity. The general coefficient obtained for the crude fibre was only 8.29 in which is included the portion soluble in chlorin. When we consider the fuel value of this cellulose, it is higher, by a little, than that prepared from the other fodders, but the coefficient of digestion is very low, only 32.51 per cent. But it is higher than the coefficient found for the crude fibre of this hay, in fact it does not agree at all, except in that it is much lower than the coefficients which we found for this portion of the other fodders. The energy of the saltbush is, in general, low. The amount of water drunk was large and the animals were permitted to drink whenever they wished to. These two things may have interfered with the digestion of the cellulose, *i. e.*, there may not have been enough energy available to effect its breaking up and to carry on the other bodily functions.

DISCUSSION OF RESULTS AND RECAPITULATION

§175. In Bulletin No. 39 of this Station, I attempted to find some way to examine a fodder which would give us more satisfactory information regarding the value of the fodder than the old method furnished. I designated it as "A Study of Alfalfa and Some Other Hays". It is now ten years since that bulletin was published and I here present a brief review of the further work done in this line, extending it very materially to include the distribution of the nitrogen in the different extracts and also that of the pentosans. Further the determinations of the fuel value of the fodders and residues obtained by exhausting the fodders with different menstrua and therewith the energy value of the extracts themselves have been added.

§176. The analytical work has been supplemented by digestion experiments made with sheep, using three individuals in each experiment. When I commenced this portion of my study, I scarcely hoped to be able to carry it to the extent that it has been carried; had I foreseen the end, I would certainly have collected the urine and included this factor in the work, but even then the work would have been incomplete, though it would have been a little more satisfactory than it is at present.

§177. It is not expected that everybody will find interest enough in this subject to lead them to read all of the analytical results to see what errors have been made, and to weigh the force of each individual result obtained, so I may be pardoned for giving, in the form of a recapitulation, a general statement of the work.

§178. The fodders studied are alfalfa hay, timothy hay, native hay, saltbush hay, *Atriplex argentea,* corn fodder and sorghum fodder.

§179. It seems superfluous to state that we used the best quality of these different fodders that we could obtain. The alfalfa was probably rather old when cut and the hay had been preserved in a stack, so that some of it was not in prime condition, but, with these two reservations, it would be classed as very good hay.

§180. The timothy hay was grown in the mountains and was as good a quality as we could obtain. The native hay was, as is all the hay to which this name is applied, a mixture of grasses and sedges, and the results obtained with one sample of it will apply only in a general way to any other sample.

§181. The saltbush, *A. argentea,* was included in this study mainly because we need a plant to use in the eastern portion of the State as a forage plant. Irrigation is out of the question in this

section of the State, and the rainfall is so light that ordinary forage plants do not furnish much forage, if they succeed in living. This saltbush grows abundantly some seasons and in some places, and the ranchmen have cut it, made it into hay and used it to feed their stock during severe storms when the cattle were unable to graze on the plains, and needed something to enable them to endure the storms which, I understand, are often severe, being accompanied by low temperatures and high winds.

§182. I do not know that anyone has observed the effects of this fodder under any conditions, favorable or otherwise, so that our observations and results will be of commercial interest to this section of the State whether they are favorable or not. Further, the saltbushes have not been studied, not even the Australian saltbush, *Atriplex semibaccata,* which is a very different and, as a fodder, I hope, a much more valuable plant than this. It has, at least, been recommended by the California Experiment Station and in a preliminary feeding experiment made by myself it promised to be a fair fodder even when fed alone.

§183. I desired to study the composition, digestibility and feeding value of this class of plants, so this native saltbush which had already been used as a substitute for our better known forage plants, seemed to me to be a subject which would answer my purpose very well indeed, and might possibly be of considerable benefit to the State. I regret that my results do not justify any hope of adding a good forage plant in this indigenous saltbush. As a subject for the study of the questions discussed in this bulletin, however, it serves my purpose very well, for it proves to be a very poor fodder, one scarcely fit to be used under any circumstances and certainly not fit for use under conditions of stress and with cattle already reduced in vitality by continued exposure and lack of a generous supply of food.

§184. This fodder probably contains nothing positively poisonous or injurious, it is simply deficient as a fodder. One of the three sheep experimented with lost only one-half pound but another lost six pounds. We will later try to point out wherein it is deficient. None of the fodders studied serve better than this saltbush to make clear our principal object in this work, *i. e.,* to discover, if possible, what causes the difference between fodders—why one is a good fodder and another a poor one—to discover some way of judging correctly whether a fodder is good or poor without having to feed it, but this is after all, a comparatively convenient, rational and conclusive method and the results obtained by it need no summing up except as to cost.

§185. The other fodders studied were corn fodder and sorghum fodder. The results obtained with these fodders, particularly

in feeding them, were wholly unexpected,in that the former gave better results than was anticipated and the latter very unfavorable ones, which was contrary to what I had expected. Even now, I am scarcely content to accept the results of our feeding experiment. As will be seen subsequently, there is nothing in the composition, judged either by the regulation fodder analysis, or by what I have called the proximate analysis, or in its fuel values to suggest an inferior value for this sorghum fodder, but each of the three sheep fed on this fodder lost very nearly three pounds in five days during which time they not only consumed but digested a very fair amount of food, three pounds per hundred weight of animal daily.

§186. Our object was primarily to study the fodders to find out how we might learn more about the reasons why fodders are so different in value. The groups into which we have been accustomed to divide fodders are not definite groups, but are the best that we have had and they have not yet been displaced. Students have long felt that the results left much to be desired and have adopted other methods of investigation, in order to find out the value of the fodders, their composition, the heat values of the components, and the energy actually furnished to the animal.

§187. It occurred to me that an endeavor to study the carbohydrates might add something to our present knowledge and I chose the line of work presented in Bulletin No. 39, but I realized that it was only an attempt and left much that was unsatisfactory. Some of the results were not concordant and the work was not carried far enough and was not accompanied by any results obtained by these lines of examination in combination with feeding tests, the results of which should serve as facts on which to base our interpretations. I have tried to obviate these faults in the investigation now presented.

§188. I have adhered to the general line of experimentation outlined in Bulletin No. 39, so that the present work may properly be considered a continuation and extension of that. The general method of examination was to exhaust the fodders with boiling 80 per cent. alcohol, cold water, boiling water and after cooling with malt extract, boiling 1 per cent. hydric chlorid, boiling 1 per cent. sodic hydrate, and lastly, with chlorin, subsequently washing with 1 per cent. sodic hydrate and hydric sulfite. I have not yet seen any good reason for changing this order of procedure. The results show, however, that it does not effect a division of the fodder into any definite groups. By this I mean that the extracts consist of mixtures of substance whose composition cannot be established in this way. I hoped, for instance, to be able to determine the sucrose in the alcoholic extract, but I find from the determinations of the furfurol removed from the fodder, that it is quite probable that the

alcoholic extract contains pentosans which may yield reducing sugars on heating with dilute acids, or inversion, so there is doubt whether sucrose, ordinary cane sugar, in a fodder can be determined in this way, especially when present in small quantities. The same is true of the starch determinations, because we found that boiling for one hour and treating with malt extract removed furfurol as in the preceding instance. This shows that the pentosans are dissolved by a considerable range of solvents. Further, we find them present in all of the extracts except possibly that obtained by the treatment with chlorin and subsequent washing with sodic hydrate and sulfurous acid to remove the products of chloridization. Some furfurol is removed from the crude fibre by this treatment but we did not find any reducing sugar in the extract obtained; it is, of course, possible that the action of the chlorin was so drastic that it oxidized and radically changed the furfurol yielding substances so that there remained no hydrolizable carbohydrates of this type in the extract. The residue left, after all these treatments, the cellulose yields from 1.6 to 2.1 per cent. furfurol, showing that substances yielding from one-sixth to one-third of the total furfurol yielded by the fodder, resist all of these treatments and constitute a portion of the cellulose thus obtained. This is probably oxycellulose which may be the source of the furfurol removed by the treatment with chlorin and the subsequent washings.

§189. Again, we find that the nitrogen content of the fodder is distributed unevenly throughout the extracts, some of it, a very little, escaping all of the solvents and remaining in the cellulose. The compounds corresponding to the amid-nitrogen are quite easily soluble and might readily pass into the 80 per cent. alcohol solution, but we find in the case of the alfalfa, for instance, that one-third of the nitrogen, calculated as proteids, is soluble in this menstruum, whereas, the amid-nitrogen, provided it were wholly soluble in 80 per cent. alcohol, could not constitute more than one-fifth of the total, showing that large amounts of nitrogenous substances other than amids went into solution. These statements will suffice to make clear the meaning of the assertion that this procedure does not effect the division of the fodder into well defined groups, and it was not expected that it would, but rather that it might enable us to find differences between the fodders which would at least help to explain the differences observed in their feeding values.

§190. It is and has been known, for the past twenty-four hundred years, that alfalfa hay is a good fodder, so there is nothing new in such a statement. The new thing is the general recognition of the fact and the interest taken in it. I have acknowledged this very generally accepted estimate of the value of this fodder in choosing it as the standard of comparison in this work. It may

not be a good standard for the comparison of all hays, as only a few of our hays are made from this class of plants, *i. e.*, the pea vine, the clovers, etc., even in my work it stands alone, a leguminous hay, though pea vine and red clover hay were included in the work presented in Bulletin No. 39. As a standard of value for different hays made from grasses it may not be a good one, but as a standard of value in this study no better one could, in my opinion, be adopted. It is a favorably known fodder, yielding good results wherever used and its use is rapidly becoming more extensive than heretofore. The results of our investigation of this hay show the following points of interest: But little danger in its use, the green plant may produce bloating in cattle and the feeding of musty and dusty alfalfa hay is charged with producing the heaves in horses, further when fed alone it produces looseness of the bowels and increased urination. These are the evils chargeable to this plant; the rest to be said is favorable, it being an excellent fodder, even for horses when fed with proper precautions, while for fattening cattle and sheep it is unexcelled. For these good reasons, I have chosen it as the first subject for study.

§191. The average composition of this hay is now very generally known; it is characterized by the presence of a high percentage of nitrogen, commonly expressed in terms of crude proteids which usually range from 12 to 15 per cent. of the hay. The group indicated by the term crude fibre is rather abundant, being from 30 to 35 per cent. in good hays, and that understood by the term nitrogen-free extract, is about the same, 30 to 35 per cent. In a general way, then, we may represent alfalfa hay as being composed of one-third crude fibre, one-third nitrogen-free extract, one-sixth proteids while the other sixth is represented by ash and ether extract. The other leguminous hay, common in some parts of Colorado, is pea vine hay. This is, when cut in full bloom, somewhat richer in proteids, with about the same, perhaps a little smaller, percentage of crude fibre and nitrogen-free extract. Red clover hay is occasionally met with and is, so far as the observations of this department go, something richer in nitrogen-free extract, but otherwise about the same as alfalfa. The leguminous hays differ from those made from grasses in that they contain less nitrogen-free extract, 30 to 36 per cent., in samples of alfalfa, third cutting, occasionally as much as 41 per cent., against 42 to 50 per cent. in the hays made from grasses. They are richer in crude fibre, ranging from 32 or 33 to occasionally 40 per cent. for alfalfa against 20 to 30 and sometimes more in the hays of the grasses. They further contain from two to three times as much crude proteid—from 11 to 17 or 18 per cent. against 5 to 9 per cent., rarely more, in that made from the grasses. Such are the differences between the two

classes of hays as shown by the ordinary fodder analyses.

§192. The differences between the hay of leguminous plants and that of grasses is further shown by the large portion removed by simple solvents such as water and alcohol. The total amount dissolved out of the air-dried hays by 80 per cent. alcohol and water in the order followed in this work is for alfalfa, 40 per cent.; red clover hay, 35 per cent.; pea vine hay, 34 per cent.; timothy hay, 31 per cent.; native hay, 30 per cent.; corn fodder, 37 per cent.; sorghum, 47 per cent., and the saltbush experimented with, 28 per cent. The 80 per cent. alcohol extracts from these air-dried fodders and hays, the following amounts: From alfalfa, 27 per cent.; corn fodder, 29 per cent.; timothy hay, 21 per cent.; native hay, 21 per cent.; sorghum, 36 per cent., and from the saltbush hay, 22 per cent. A quantity of alfalfa was digested with cold water for 24 hours and the loss then determined, when it was found to be 40 per cent. Apparently then, water alone will remove from alfalfa as large an amount of extractives as alcohol and water when used successively; this was not established by repetitions of this experiment. No precaution was taken against fermentative changes. This result is consonant with the well known susceptibility of alfalfa to injury by moisture, even a heavy dew sufficing to discolor it. I did not submit the hay to the ordinary fodder analysis after treating it in this manner. The results would doubtlessly have been interesting if I had done so, but I have an old analysis of a hay damaged by a succession of showers necessitating the exposure of the hay to both extraction and fermentation. Making no allowance for the large loss of weight, which must have been suffered in this case, we have the following difference in the hay as cut and gathered: Crude fibre as cut 26.46 per cent., as gathered 38.83 per cent.; crude proteid as cut 18.71 per cent.; as gathered 11.01 per cent.; and the nitrogen-free extract 38.91 per cent. as cut, and 33.64 per cent. as gathered. These results are affected by the mechanical losses as well as chemical, but they serve to suggest that it is not only an important consideration for the farmer but a good point of attack for the student of such subjects. The hays made from the grasses, and the native hay, being a mixture of grasses and sedges, may in this respect be fairly representative of such as are usually used in hay making, yield just about one-half as much to alcohol and water as the leguminous hays.

§193. The other well known class of fodders represented in our study is corn fodder. The dry matter of this fodder differs according to the ordinary fodder analyses from that of the leguminous hay in containing nearly one-half more nitrogen-free extract, and from one-third to one-half as much crude proteid, while the

crude fibre is not far from the same, though not nearly so constant, being sometimes more and sometimes less.

§194. The solubility of the nitrogenous substances of these different fodders in 80 per cent. alcohol may further exhibit their differences, as well as the extent to which these substances are soluble in this medium. The nitrogen has, of course, been calculated as proteids by multiplying by 6.25, the usual factor. The following table gives the weight in grams of the proteids in the fodders fed, and the amount which was soluble in the respective solvents.

TABLE CIV.

	Alfalfa	Corn fodder	Timothy	Native hay	Saltbush
80% alcohol	640.0	249.0	189.0	231.0	692.0
Cold water	91.0	33.0	83.0	70.0	57.0
Hot water and malt	135.0	27.0			108.0
1% hydric chlorid...	127.0	79.0	99.0	98.0	133.0
1% sodic hydrate ...	937.0	116.0	350.0	384.0	618.0
Chlorin	45.0	30.0	13.0	29.0	236.0
Residue or cellulose.	17.0	6.0	9.0	11.0	29.0
Total proteids fed ..	1992.0	540.0	743.0	823.0	1873.0

§195. We see that the two hays, timothy and native hay, yield between one-quarter and one-third of their nitrogen to the alcohol, which is nearly as high a ratio as in the case of alfalfa and the saltbush. The maximum relative portion is observed in the case of the corn fodder in which the amount dissolved amounts to nearly one-half. There is either no relation between the soluble nitrogen and the value of the fodder, or it is so greatly modified by other factors that it is entirely concealed. Of these fodders, alfalfa produced the largest results, *i. e.*, 9 pounds of flesh in five days; the corn fodder and native hay next with 3½ pounds each; the saltbush and sorghum last with a loss of 8½ pounds each.

§196. The amount of nitrogenous matter dissolved out of the hays by water, after previous treatment with the 80 per cent. alcohol is very small, but the loss of the alfalfa hay which has been exposed to the rains suggests, at least, that the nitrogenous matter soluble in the alcohol may also be soluble in water. Be this as it may, neither cold or boiling water removed any very considerable portion after the previous treatment with alcohol. The two exceptions to this are the saltbush and the alfalfa. We also notice that it is these two, saltbush and alfalfa, from which the 1 per cent. hydric chlorid removes the largest quantities of the proteids, that is, absolutely but not relatively, for in the alfalfa, for instance, about one-sixteenth of the nitrogen is dissolved out by the 1 per cent. hydric chlorid, while in the corn fodder and timothy hay it is about one-seventh.

§197. The similarity between the alfalfa and the saltbush in regard to the amount of proteids present and their solubility in these solvents is striking and two things regarding them is very evident, *i. e.*, while one-half of the proteids were removed from the alfalfa by the 1 per cent. sodic hydrate, only one-third of them was removed from the saltbush, but the amount removed by chlorin and subsequent washing with 1 per cent. sodic hydrate and hydric sulfite is five times as great. The relative quantities, owing to the fact that the quantities fed were so nearly alike, are the same, *i. e.*, one-fortieth and one-eighth respectively. The nitrogenous substances removed by the chlorin and the subsequent washings usually amount to but a few grams and are apparently often more abundant in the feces than in the hay or fodder, but in the saltbush hay such proteids(?) are unusually abundant and they have a coefficient of digestion, according to our experiments, of about 29 per cent., which is, of course, very low. We evidently have to do with nitrogenous substances quite different in character and while our division of them into groups is not satisfactory, we still have three big groups, those removed by 80 per cent alcohol, always with a good or even high coefficient of digestion; those soluble in hydric chlorid differing very much in their digestibility, from 39 to 63 per cent. in the different fodders, and those soluble in sodic hydrate which have high coefficients of digestion, except in the case of the corn fodder in which this group of nitrogenous substances is not nearly so large as in the other fodders and is, apparently, so good as indigestible. The proteids soluble in cold and hot water are not considerable in quantity, except in the alfalfa and saltbush, and are not very digestible, while those removed by chlorin, etc., are small in quantity, except in the case of the saltbush, in which they constitute an eighth of the total, and either show a low coefficient of digestion, 29 per cent. in the case of the saltbush, or are more abundant in the feces than in the fodder fed.

§198. What the bearing of these facts may be on the feeding values or properties of the fodders is not clear.

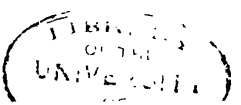
§199. It may be well to consider some facts, as well as we may, but without assuming that we know anything about them. The alfalfa and saltbush, for instance, constitute the extremes in our series of fodders, perhaps I should, to be logical in interpreting our results, class sorghum and saltbush together. As already stated, I cannot but entertain a strong opinion that the sorghum should be studied further, because of the very unfavorable results obtained. It must, however, be acknowledged that the results in the case of the three sheep were uniform and unfavorable, though the fodder was apparently of excellent quality and in very good condition. The results showed a loss of almost three pounds in each of

the three sheep, which certainly ought to have more weight than my opinion that the sorghum is a better fodder than these results indicate. We did not make as full a study of the sorghum as of the other fodders and for these two reasons I have less to say about the sorghum than about the others.

§200. With this explanation regarding the sorghum, I will consider the saltbush as constituting the most inferior fodder of the series, and yet, as stated before, this fodder is richer in proteids than either of the remaining five, alfalfa alone excepted. With the alfalfa, we fed, in round numbers, 2,000 grams of proteids, coefficient of digestion 72.5, with the saltbush practically 1,900 grams, coefficient of digestion 66.4. The three sheep fed on alfalfa gained 9 pounds, those fed on saltbush lost 8½ pounds. It is, of course, wholly improbable that other constituents had no disturbing effects on the results, but it is also very probable that the nitrogenous substances soluble in the different reagents are of very different value and it is not the amount of the proteids (N x 6.25) present, but their character which determines their value. It may be that the large amount of chlorin-soluble nitrogen present in the saltbush, constitutes not only an analytical difference, but a nutritive one also. It is evident that the sheep digested rather more proteids when fed on alfalfa but the difference is not very big, 239 grams. The amounts of proteids digested where corn fodder was fed were quite small, less than one-fifth of that digested in the case of the saltbush and one-sixth of that in the case of the alfalfa. The amount digested when native hay was fed was less than one-half of that digested in the case of the saltbush. Both the native hay and corn fodder proved to be good fodders, all of the sheep gaining while receiving them; the aggregate gain in the two lots of three sheep each, was three and one-half pounds for each lot.

§201. The animals were not fattened on these fodders and killed to see the relation of muscle to fat, so I do not know anything about this feature of their effects. The amount of the alcohol-soluble proteids in the corn fodder is larger than that in any of the other solvents, being 217 grams out of a total of 473 grams. In the case of the native hay the two solvents removing the largest quantities of proteids are the sodic hydrate and alcohol. The contrast in the results produced in these experiments is that the sheep receiving saltbush digested 1,091 grams of proteids and were losing flesh, some of them rapidly; those receiving the other fodders were gaining, though they received much smaller amounts of proteids with either the corn fodder or native hay and only 239 grams more when fed alfalfa, but in this case the lot made a gain of nine pounds against a loss of 8½ pounds in the lot receiving saltbush.

§202. The question which I have tried to present is, do the



facts exhibited by the results of this proximate analysis offer any suggestions regarding the reasons for so great a difference in the feeding values of these fodders.

§203. We will later give a reason for the assertion that the alcoholic extract is the most important portion of the fodder and we observe that the proteids of the saltbush, soluble in alcohol and digestible, is greater even than in alfalfa, so that it would seem probable that this portion of the saltbush, unless it should contain some therapeutically active and deleterious substance, is probably the most valuable portion of this fodder, but if the fuel values are safe criteria, it is of comparatively small value compared with that of the corresponding alfalfa extract, giving a little over one-half the energy. This, of course, applies to the whole extract from which we cannot single out the effect of the nitrogenous matter.

§204. The carbohydrates in the alfalfa and the saltbush are evidently quite different; if we take the total sugars as the measure, they stand as 9 to 26, there having been fed with the alfalfa, carbohydrates capable of giving 900 grams of sugars, while the saltbush gave 2,600 grams. The furfurol also indicates a great difference. There was consumed with the alfalfa 1,030 grams of furfurol and 1,524 grams with the saltbush. The coefficient of digestion for the furfurol in the alfalfa was 65.2, and for that in the saltbush 37.4. The weight of alfalfa fed was 13,351 grams, and of saltbush 16,088 grams. The difference in the coefficients of digestion is also very marked, 37.4 in the case of the saltbush and 65.2 in that of the alfalfa. The difference in the character of the carbohydrates is still further indicated by the low degree of digestibility shown by the residue, which I have for convenience sake called cellulose, which is 29 for that from the saltbush and 53 for that from the alfalfa. The action of chlorin, together with the subsequent washing with sodic hydrate and sulfurous acid does not show as great a difference in these cases as in that of some other fodders, though the amount removed from the saltbush is the greater by about 1.6 pounds per hundred. This portion of the fodder seems to be uniformly very difficult of digestion, the coefficient in the case of the saltbush being but 6.3. I have elsewhere suggested that the low coefficient uniformly obtained for this portion of the fodder may be apparent only, due possibly to a close resemblance between it and fecal matter, as we have found this portion in the feces larger than the total fed in several instances. The hydric chlorid with which the fodders were boiled till no more sugars were produced, also shows a decided difference. The alfalfa consumed, 12,364 grams, yielded but 340 grams of sugar, calculated as galactan, whereas the 16,088 grams of saltbush yielded 1,455 grams of sugar calculated as xylan; here again the coefficients of digestion indicate wide difference of proper-

ties. The alfalfa sugar, galactose, shows a coefficient of 84, and the saltbush sugar, xylose, a coefficient of 58.6.

§205. The nitrogenous substances may contribute a small proportion of these sugars, but they undoubtedly are, for the most part, derived from other compounds.

§206. The difference in the coefficients of digestion for the respective residues becomes still more significant when it is called to mind that this residue is one of the three important portions of the fodder, as will be more fully shown under the discussion of their relative heat values. We will find that the coefficients of digestion, 53 for the residue from the alfalfa and 29 for that from the saltbush, are not consonant with the heat values obtained, but still we will see that they are nearly so and that the saltbush residue yielded less than three-fifths as much energy per unit of weight as that from the alfalfa.

§207. The corn fodder was found to be a good fodder, producing a gain of 3½ pounds in the three sheep. There was digested by the sheep in this instance 4,940 grams of dry matter, equal to 56.3 per cent. of that consumed, 1,789 grams of which was soluble in alcohol, 1,245 grams soluble in hydric chlorid, and 1,210 insoluble.

§208. In this case the sugars indicate the presence of a large portion of alcohol-soluble carbohydrates, glucose and cane sugar, together amounting to 872 grams, which is wholly digestible, and 975 grams in the form of galactan and xylan, sugars inverted by the action of the dilute hydric chlorid; these practically constitute the whole of this class of substances in the corn fodder, as cold water, hot water and sodic hydrate together remove but 100 grams of sugars from the whole amount of corn fodder consumed; the cellulose is, of course, to be added to these to obtain the total carbohydrates. The furfurol removed by alcohol is very small in amount, so that while some pentosans are present the amount is at most, insignificant; 77.5 grams were consumed and the coefficient of digestion was found to be 94.8 per cent., so, aside from our knowledge of the fact that sucrose and reducing sugars occur in the juices of the corn stalk, there is no question but that the sugar found did not come from the inversion of other carbohydrates. The total amount of furfurol found to have been removed by hot water and malt seems to be open to question, as our duplicate determinations did not agree very well. The hydric chlorid extract furnished very nearly one-half of the sugars found and a little more than one-half of the furfurol found in the extracts of the fodder; this, of course, does not include the residue or cellulose.

§209. The amount of proteids consumed with the corn fodder was much less than in the other two instances, alfalfa and saltbush. With the alfalfa 1,817 grams were consumed and 1,325 digested;

with the saltbush 1,646 grams were consumed and 1,090 grams digested; but with the corn fodder there was only 473 grams of proteids consumed and 179 grams digested. This fodder seems to give favorable results, though the composition of the fodder is very different from the others in respect to the amount and character of the carbohydrates and also in regard to the proteids, the latter, in particular, being largely soluble in the 80 per cent. alcohol. This is especially noticeable with the portion digested, as 141 grams out of the 178 digested were soluble in the alcohol. Another point of difference between the proteids of these three fodders is the low degree of digestibility of the proteids contained in the corn fodder. This is true with both the general coefficient and the coefficients obtained for the proteids in the extracts. The general coefficients of digestibility for the proteids are 73 for those of the alfalfa, 66.4 for those of the saltbush, and 36 for those in the corn fodder. Alcohol dissolves approximately one-third of the total proteids out of alfalfa, and these have a coefficient of digestion of 81.7; from the saltbush a trifle more than one-third, and the coefficient of digestion was found to be 88; from the corn fodder, it dissolves a little less than one-half of the nitrogen, calculated as proteids, of which 65.5 per cent. was found to be digestible.

§210. The other solvents removed quite small amounts of proteids from the corn fodder and these have quite low coefficients of digestion. The sodic hydrate dissolves the second largest portion of the proteids out of the fodder, but it is so good as indigestible. This is in marked contrast with the other fodders, in which cases the amounts of proteids dissolved out by the sodic hydrate are both absolutely and relatively much greater, and the coefficient of digestion is high in each case, 82 for that of alfalfa and 70 for that of the saltbush, against zero for that of the corn fodder. It is possible that the coefficient obtained for this portion of the proteids is erroneous, but it is not probable, and it is safe to assume that the coefficient of digestion of this portion of the proteids in corn fodder is very low, indeed, probably zero, as above stated.

§211. The most notable features so far developed are that the soluble carbohydrates, *i. e.*, all that portion of the fodders not included under the proteids, and the residue or cellulose vary within narrow limits, except for those soluble in hydric chlorid. The most important extract is that obtained by alcohol, in which, it is true, that large quantities of proteids occur, but their coefficient of digestion is, in the cases of the saltbush and corn fodder, less than the general coefficient for the extract, so that the coefficient for the carbohydrates must be higher than that found for the extract. This does not hold for the alfalfa. The coefficients of digestion found for the alcoholic extracts of these three fodders are as follows—alfalfa,

68.6; saltbush, 70.5; corn fodder, 73.8. We see that they are quite close together, and as the percentage of the respective fodders soluble in alcohol are not very unlike, it seems just to assume that in the absence of any injurious constituent they have approximately the same value, but such is not the case, as is indicated by the heat values appropriated by the animals, according to which the relative values of the three alcoholic extracts stand as 1 to 1.5 to 1.9 nearly. The alfalfa extract having a value of 1.9 and that of the corn fodder 1.5, if the saltbush extract be taken as 1. The second important division of the carbohydrates is represented by the hydric chlorid extract and here we find very great differences indicated by the coefficients of digestion. This portion of the alfalfa has a coefficient of 60.2; that of the corn fodder 69.4, while that of the saltbush has a coefficient of only 39.9. The percentage of this portion present in these fodders was found to be as follows: Alfalfa, 12.2; corn fodder, 18.9, and saltbush, 17.0. We observe that the coefficient of digestion for this group of substances in the saltbush is low and the percentage of it present in the hay is high, from which standpoint it would be an important factor in judging of the value of the fodder. The coefficients of digestion found for the corresponding heat values were, for the alfalfa, 54.75; for the corn fodder, 63.88, and for the saltbush, 40.7. The indication of these coefficients, too, is that this portion of the saltbush extract is inferior to that of the other two. The heat appropriated by the sheep per gram of this extract consumed, stood in the ratio of 1.3 to 1.8 to 2, the saltbush again being the lowest and the alfalfa the highest. The deportment of the proteids present in these different fodders has been referred to in a previous paragraph, where it is shown, though not explicitly stated, that the proteids in the saltbush resemble those of the alfalfa in their quantity and deportment toward the different solvents, so here we find the proteids in the alcoholic extract of the corn fodders relatively high and those of the alfalfa and saltbush relatively low, but the absolute amount of proteids in the hydric chlorid extract of the corn fodder is small and of no significance, while the actual weight of the proteids dissolved out of the alfalfa and saltbush, respectively, is much greater than in the case of the corn fodder, but it is not sufficiently large to materially modify the statements made relative to the value of the carbohydates represented by this portion of the fodder.

§212. The sodic hydrate extracts of the three fodders differ greatly; that from the alfalfa shows a coefficient of digestion of 67.7, but about 43 per cent of the total extract is proteids (N. x 6.25); that of the corn fodder is poor in proteids and has a coefficient of only 36.3, while that from the saltbush is richer in proteids, about 20 per cent. of the extract consumed being proteids, and has

a coefficient of digestion of 49, but that of the proteids contained in this extract is 70, so that the substances, other than proteids in this extract must have a low coefficient, which is consonant with the result obtained in the case of the corn fodder. The portion of this extract, sodic hydrate, having the greater value is probably the nitrogenous substance, while the carbohydrates possess the lesser value.

§213. None of our results are more instructive probably than those shown by the portion which resists the action of our solvents, even the chlorin followed by the caustic soda and sulfurous acid. We find that this residue from the alfalfa hay has a coefficient of digestion of 52.8, and that from the corn fodder a coefficient of 54.0 per cent. The boiling one per cent. solutions of hydric chlorid and sodic hydrate are pretty active agents, but moist chlorin is much more active, still the animal digestive processes effect the solution of upwards of 50 per cent. of the material in the good fodders, alfalfa and corn fodder, which has resisted these agents, while in the poor fodder, saltbush, these processes are capable of bringing only 29 per cent. of this residue into solution. It will be shown a little later that the heat values show a similar result.

§214. There is no evidence, that I have discovered, that the saltbush had any deleterious effect on the sheep, though I have been told that it acts as a laxative on cattle, and it did induce excessive thirst and urination in the sheep experimented with. There were no indications that the sheep were in the least uncomfortable. While the nitrogenous substances in this forage may be inferior in value to those in the alfalfa, there is no proof that they are. Two things are, however, clear—that they are much more abundant and have a much higher coefficient of digestion than those of the corn fodder; in fact, this fodder approaches the alfalfa in this respect more closely than either of the other fodders used in the experiment, and while I know nothing relative to the fuel value of the nitrogenous compounds, it may be assumed that the differences are not sufficient to completely reverse the indications given by the coefficients of digestion obtained for the proteids, according to which the saltbush should have a very much higher feeding value than the corn fodder, and nearly equal to that of the alfalfa. On the other hand, all of the data obtained indicate that the carbohydrates, whether soluble in the various menstrua or not, are difficultly digestible and, taken all together, are of low fuel value. This is particularly the case with the two important portions, the portion removed by hydric chlorid, 1 per cent. solution, and the cellulose or residue, the former having a coefficient of digestion of 39.9 and the latter of 29.0 per cent., as against 69.4 and 54.0 per cent., respectively, in the corn fodder. The factor in this fodder which seems to determine its feeding value is

the character of the carbohydrates that it contains. The nitrogenous matters contained in the saltbush are abundant and are highly digestible. The carbohydrates are resistant to the processes of digestion. The sheep digested large amounts of protein, 1,090 grams, but relatively small amounts of carbohydrates, and the lot lost 8½ pounds in five days. The results obtained with this fodder are in strong contrast with the other two; with the alfalfa the sheep ate and digested large quantities of both nitrogenous compounds and carbohydrates, both those soluble in hydric chlorid, 1 per cent. solution, and those which resisted the action of all of our solvents; with the corn fodder, they consumed a relatively small amount of nitrogenous compounds, having a low coefficient of digestion, 37.7 per cent., and a relatively large amount of carbohydrates with a high coefficient of digestion. The total amount of dry matter consumed as corn fodder was smaller than with any other fodder used, still each of the animals gained flesh, the lot gaining 3½ pounds in five days.

§215. The urine was not collected in any instance, an omission which is especially regretable in the case of the saltbush, because a large amount of nitrogenous matter was digested and there was a pronounced loss, especially with one of the sheep, 6 pounds. This is the only case in which we found marked differences in the individuals, but we did observe that one of the animals evidently did not like portions of the timothy, and while two of them lost a little, one gained a little, while on an exclusively timothy ration. With the other fodders, they either all lost or all gained. With the alfalfa they each gained three pounds, with the sorghum they each lost about three pounds, with the corn fodder and native hay they each gained, the total gain for each lot being three and one-half pounds.

§216. The other fodders, timothy hay, native hay and sorghum, were not studied to the same extent as those already given. Of these three, the native hay is the only one on which the lot made a gain; one sheep made a gain of one-half a pound on the timothy, but each of the others showed a loss, so that the lot showed a slight loss.

§217. As the same general result, *i. e.*, a gain of three and a half pounds in each case, was obtained with the corn fodder and native hay, we will present the salient points in the character of these fodders so far as we can; the alcoholic extract of the corn fodder furnished 1,789 grams of digestible matter, 73.79 per cent. of the total extract; that of the native hay furnished 1,297 grams, 58.55 per cent of the total; the hydric chlorid extract of the corn fodder yielded 1,245 grams digestible matter, equal to 69.42 per cent. of the extract; that of the native hay 1,422 grams, equal to 64.04 per cent. of the extract; the sodic hydrate extract of the corn fodder yielded

342 grams of digestible matter, equal to 36.27 per cent. of the extract; that of the native hay yielded 575 grams, equal to 32.79 per cent. of the extract; the residue or cellulose from the corn fodder yielded 1,210 grams of digestible matter, equal to 54 per cent. of the residue and that of the native hay yielded 1,502 grams, equal to 50.57 per cent. of the residue.

§218. In the case of the timothy hay, the values of the respective extracts stand in the same order, but the digestible matter furnished in each case, the sodic hydrate extract excepted, is less than in the two preceding cases; the alcoholic extract furnished 1,085 grams of digestible matter; the hydric chlorid extract 1,099 grams; the sodic hydrate extract 733, and the residue of cellulose 932 grams. The digestible proteids (N. x 6.25) in these extracts were determined; in the alcoholic extract there were 129 grams; in the hydric chlorid extract 23 grams, and in that obtained by means of sodic hydrate 136 grams. The digestible proteids in the corresponding extracts of the corn fodder were found to be 141 grams in the alcoholic, 28 grams in the hydric chlorid, and none in the sodic hydrate extract. We see again, in the timothy hay, as in the salt-bush, that a larger amount of proteids were digested and a decidedly smaller amount of carbohydrates, the most marked deficiency being in the portion designated as residue or cellulose. The feeding results were a loss in both cases, though with the timothy hay, it was only slight, and one sheep showed a slight gain, but this sheep digested two-thirds more crude fibre than either of the other two. This may, however, be an accident only. The proteids in the various extracts of the native hay were not determined.

§219. The extracts of the sorghum stand in the same order as those of the corn fodder, and the amount of digestible matter contained in the alcoholic extract is much larger, nearly twice as large, but that furnished by the hydric chlorid extract and by the residue or cellulose, furnishes one-sixth less than in the case of the corn fodder.

§220. So far as our analytical results and also the energy values obtained are reliable criteria, sorghum fodder would appear to be a good one, but the results as indicated by the weights of the sheep at the beginning and end of this experiment indicate that it is a poor fodder. The results were uniform, *i. e.*, each of the sheep lost three pounds and the conditions of the experiment were as favorable as we could make them; everything, in fact, was in favor of obtaining good results with this fodder. The weather was fair and moderately cool. The sheep were used to being handled. They fed freely and were allowed a liberal ration, still they lost weight, and the same sheep gained when fed on corn fodder, so that the individuality of the sheep is eliminated so far as this comparison of

the corn fodder and sorghum is concerned. As I have elsewhere stated, any inferences from the analytical results or determinations of the fuel values and all personal opinion regarding the value of such sorghum fodder must be held in abeyance when the feeding results are so strongly against them.

§221. I do not know what the general judgment relative to the value of this fodder is, but Mr. Payne, who grew this sorghum, tells me that he and the party who joined him in his work with this sorghum, came to the conclusion that when fed alone it was of no value, which agrees with the results of my feeding experiments.

§222. The pentosans as represented by the furfurol show very marked differences. The four portions of the fodders which are of the most importance cannot be designated as in the case of the extracts, because they vary with each fodder. The alfalfa was beyond all question the best fodder experimented with, and we find considerable quantities of furfurol in each of the extracts made, but the three most important portions of the hay in furnishing digestible furfurol were the alcoholic and hydric chlorid extracts and the residue or cellulose. The sodic hydrate removed more furfurol from the fodder than any other solvent, but its coefficient of digestion is very low, 27.80 per cent., while the coefficient of digestion for the whole extract was high, 67.7 per cent. Cold water, hot water and malt extract and chlorin, with the subsequent washing with sodic hydrate and hydric sulfite, each remove some furfurol, but the quantities are relatively small and the coefficients of digestion vary greatly, which, owing to the relatively small quantities involved, is probably a matter of small importance. This class of substances, the pentosans, constitute about one-eleventh of the total dry matter digested by the sheep fed on alfalfa, about one-tenth of that digested as corn fodder and about one-thirteenth of that digested as saltbush, which is the smallest amount found in any of the six fodders.

§223. The fodders which stood nearest in value to the alfalfa were the native hay and corn fodder. This does not mean that they were nearly equal to it by any means, but the two fodders giving the next best results measured by the increase in the live weight. The lot receiving alfalfa gained nine pounds, while the lots receiving native hay and corn fodder, respectively, gained three and one-half pounds each. The lot receiving timothy hay lost one pound. The timothy and native hays are representative of the small grasses, as distinguished from the corn fodder, and are more nearly alike so far as the distribution of the pentosans is concerned than the native hay and corn fodder. From the smaller grasses, timothy and the native grasses, the largest quantities of furfurol are removed by the hydric chlorid and sodic hydrate. The next largest portion remains in the residue or cellulose. The coefficients of di-

gestion of the furfurol contained in the respective portions of these hays are very different. The furfurol removed by the hydric chlorid has a coefficient of 32.8 in the case of timothy hay, and 44.04 in the native hay; that removed by the sodic hydrate has a coefficient of 11.54 in the timothy and 42.16 in the native hay, and that remaining in the cellulose has a coefficient of 50.12 per cent. in the timothy and 74.94 in the native hay. The furfurol in some of the other extracts shows higher coefficients of digestion, but owing to the smaller quantities concerned are of less importance.

§224. The amount of furfurol in the cellulose is usually large. In the cellulose from the alfalfa, 235.7 grams; from the timothy, 197.1 grams, and from the native hay, 219.1 grams. The alfalfa and native hays proved to be good fodders, the timothy hay a poor one.

§225. The distribution of the furfurol in the different portions of the corn fodder agrees with that of the hays already mentioned, in regard to the hydric chlorid and the sodic hydrate extracts, but the cellulose shows less furfurol and it has a very much lower coefficient of digestion. In the case of the corn fodder, the hydric chlorid extract shows the largest amount of furfurol, 371.8 grams, with a high coefficient of digestion, 66.25. The sodic hydrate extract consumed contained 236 grams of furfurol, coefficient of digestion 31.82. The next extract in importance, as indicated by the furfurol, was the hot water extract, in which the furfurol was wholly digestible. I have very strong misgivings as to the correctness of this determination and, for this reason, have attached but little importance to it; if, as I surmise, there is an error in this determination, it will increase the relative importance of the hydric chlorid extract. This corn fodder proved as efficient as the native hay in results obtained, *i. e.*, a gain of 3½ pounds live weight in the lot fed, but this lot did not consume as much dry matter by 1,811 grams as the one receiving native hay. The general coefficient of digestion obtained for the furfurol in corn fodder was found to be 60.19 per cent., which does not agree with that obtained by taking the sum of the furfurol found in the different extracts, being about 12 per cent. higher.

§226. It will be observed that on three of these fodders, the respective lots of sheep gained, and on the other three the lots lost. I have already mentioned timothy hay as one in which the lot receiving it lost in weight. The other two were sorghum and the saltbush, *Atriplex argentea*. Regarding the distribution and digestibility of the furfurol, representative of the pentosans, we find that in the sorghum, the three portions, the hydric chlorid extract, the sodic hydrate extract and the cellulose, contain practically the whole of it, and that the furfurol shows the following coefficients of diges-

tion, 45.72, 25.44 and 48.72, respectively. In the saltbush we have to add the aqueous extract to the above. The alcoholic extract removed no furfurol or equivalent pentosan, but both glucose and sucrose were present and the extract was abundant, 3,197 grams of it having been consumed. The next salient feature in this connection is the low coefficient of digestion found for the furfurol, *i. e.*, 37.37; the pentosans extracted by the 1 per cent. solution of hydric chlorid are indigestible in this case, whereas it is highly digestible in the alfalfa and corn fodder and has a coefficient of 44.04 in the native hay. The coefficient of digestion for the furfurol in the cellulose of the alfalfa and native hay is 72.6 and 74.9, respectively, and is very low in that of the corn fodder, 32.57. There is no means of judging how much pith cellulose is represented in this corn fodder, and I know nothing about the deportment of this variety of cellulose. It is quite possible that this may have a noitceable influence on this result. In the three fodders which we find to be inferior or poor, timothy, sorghum and saltbush, we have low coefficients for the furfurol, the general coefficients being 36.24, 46.46 and 37.37, respectively, and for the furfurol in the cellulose 50.12, 48.72 and 26.49, respectively.

§227. I will again call attention to the fact that the cellulose obtained as the result of these treatments has, as a rule, a fairly high coefficient of digestion in those fodders which proved to be the best ones, in alfalfa 52.8, in corn fodder 54.0, in native hay 50.6, but lower in the other three, timothy, sorghum and saltbush, 41.6, 47.4 and 29, respectively. The digestible proteids in these fodders were in the alfalfa 1,325.09 grams, in the native hay 366.55 grams, and in the corn fodder 178.46 grams; these are the three fodders which caused the sheep to gain, the other three, timothy, sorghum and saltbush, caused them to lose. The following amounts of proteids were digested while the sheep were on these fodders, with the timothy 234.42 grams, with the sorghum 300.91 grams, and with the saltbush 1,089.80 grams, so that the loss is scarcely to be attributed to a lack of digestible proteids. The sheep digested almost as many grams of proteids with the sorghum as with the native hay and almost 1½ times as much as they digested in the form of corn fodder. They digested six times as much in the form of saltbush as in that of corn fodder, and while the one lot gained 3½ pounds on the corn fodder, the other lot lost 8½ pounds on the saltbush. My interpretation is that the differences in the results point to the absence of a sufficient amount of easily digestible carbohydrates in the timothy hay, sorghum and saltbush.

§228. I have in mind a little more definite idea when I use the term easily digestible than we sometimes have when we use this term. I do not simply mean that large quantities of the carbohy-

drates are taken up and a condition of comfort and general well being produced in the animal, but that the amount of energy necessarily used up in carrying on the animal functions while on the fodder and that used up in transforming the fodder constituents into forms which are assimilable by the animal are relatively small. In the case of the corn fodder, we observe better results with lower consumption of dry matter and energy than in the native hay—the two fodders producing the same results—while still larger quantities of both dry matter and energy were appropriated with the sorghum and saltbush, resulting in a loss instead of a gain. There was evidently more energy available for the production of flesh in the case of the corn fodder than in the two latter cases, though the total energy used up was less.

§229. We cannot present so full an account of the heat or energy relations of these fodders. We have determined the general values for all of the fodders, but have studied only three of them in detail. The amount of heat appropriated by the sheep from the respective fodders was as follows, given in small calories: Alfalfa, 30,955,663; sorghum, 25,088,621; saltbush, 23,149,533; native hay, 22,255,418; corn fodder, 19,424,180; timothy hay, 17,406,363 calories. We see that the energy appropriated by the animals does not stand in the order of the gain or loss. Alfalfa produced the greatest gain, and sorghum the greatest loss, with the saltbush very close to it. The native hay and corn fodder each produced a moderate gain, while the timothy produced a slight loss. As the urine was not collected, it could not be examined, and we do not know how much of the energy appropriated was voided in this form.

§230. The amounts of dry matter digested in the experiments with these several fodders were as follows: Alfalfa, 7,734 grams; saltbush, 7,351 grams; sorghum, 6,725 grams; native hay, 5,392 grams; corn fodder, 4,940 grams; timothy hay, 4,501 grams. We see that the order is the same as in the case of the heat or energy appropriated. The greatest gain, that made on alfalfa, agrees with the greatest amount of heat appropriated and the largest amount of dry matter digested, but the next two fodders on which gains were shown are not the next in the order of the energy appropriated or the dry matter digested, but form the fourth and fifth in this order, the timothy standing only about 2,000,000 calories below the corn fodder. The lot receiving the sorghum and appropriating 25,088,621 calories, showed a loss of 8½ pounds, and the one receiving the saltbush and appropriating 23,149,533 calories showed a loss of 8½ pounds, while that receiving timothy and appropriating 17,406,363 calories lost but one pound, and that receiving corn fodder and appropriating 19,424,180 calories gained 3½ pounds.

§231. It would seem then that it is not merely a question of the amount of energy that disappears or is appropriated, that produces the beneficial effects of a fodder, but that these may depend upon other factors, for instance, the amount of energy used up in the process of digestion. We have in the case of the corn fodder favorable results with smaller quantities of material than with any other fodder. We have 4,940 grams of dry matter digested which contained 178.46 grams of proteids, 1,734 grams of carbohydrates as sugars and pentosans, 1,211 grams as cellulose, and 1,817 of extractive matter, not more specifically classified, and from this the animal appropriated 19,424,180 heat units and showed a gain of three and one-half pounds of flesh. On the other hand, we find that the lot fed on the saltbush digested 7,351 grams of dry matter containing 1,090 grams of proteids, 1,280 grams of carbohydrates as sugars and pentosans, 2,064 grams of cellulose, and 2,917 grams of extractives which we have not endeavored to more nearly classify, and from this the animals appropriated 23,149,533 calories, losing at the same time eight and one-half pounds. It is just that I should repeat that, while each of the three sheep lost, one of them lost but one-half pound, but the aggregate for the lot was 8½ pounds.

§232. The heat values of the various extracts of the alfalfa, corn fodder and saltbush were determined, and we found that, as a source of energy, the portion that I have designated cellulose is one of the most important.

§233. I have designated it cellulose to distinguish it from crude fibre, because the portion usually designated as crude fibre was treated in a moist condition with chlorin and then washed and boiled with one per cent. sodic hydrate and subsequently with sulfurous acid. This treatment with chlorin, etc., removed a considerable portion of the energy, but this energy is of little value in any of the fodders, the greatest value being observed in the case of the alfalfa, in which 24.0 per cent. of this energy was appropriated, but in the saltbush and corn fodder it was of no value. The total amount of energy removed from the crude fibre of the saltbush by this treatment was 8,508,528 calories out of a total of 59,205,951 for the hay, and from that of the alfalfa 6,045,840 calories out of a total of 49,585,495 calories fed. The relative quantity of heat removed from the crude fibre of the corn fodder by the chlorin is much less, *i. e.*, 1,482,734 calories out of a total of a little over 25 millions consumed and was wholly non-available. The alcoholic extract is again shown to be the most important portion of the fodder. The heat appropriated from this portion of the alfalfa was 10.7 millions calories out of a total of 30.9 millions; from that of the corn fod-

der, 7 millions out of a total of 19.4 millions, and from that of the saltbush, 5.8 millions out of a total of 23.2 millions.

§234. The second portion in importance was not the same in the three fodders, it being the sodic hydrate extract in the alfalfa and saltbush and the cellulose in the corn fodder. In the alfalfa 8.2 millions calories and in the saltbush 5.5 millions calories were appropriated from the sodic hydrate extracts, but this extract of the corn fodder furnished only 2.1 millions calories. The third protein in importance in the alfalfa and saltbush was the cellulose, which furnished 5.95 millions and 4.4 millions calories, respectively, in these cases. The fourth one in order of value is, in the alfalfa and saltbush, the hydric chlorid extract, from which the sheep appropriated 3 millions and 4 millions calories, respectively. The extracts of the alfalfa have, in the order given, furnished the larger amounts of heat, both absolutely and relatively, but this is reversed in the hydric chlorid extract, that of the saltbush furnishing the larger quantity. The order of extracts of the corn fodder in regard to their heat value is a different one, the alcoholic extract standing first, the residue or cellulose standing second, the hydric chlorid extract standing third, and the sodic hydrate extract falling to the fourth place. In the alfalfa and saltbush, we have a large amount of proteids, but we have seen that these are very freely dissolved by the alcohol and are represented almost as largley by the alcoholic extract as by that of the sodic hydrate, as the following amounts digested in the two extracts will show:

Alfalfa .....Alcoholic extract, 486 grams; sodic hydrate, 698 grams
Saltbush .....Alcoholic extract, 553 grams; sodic hydrate, 378 grams
Corn Fodder .....Alcoholic extract, 141 grams; sodic hydrate, 000 grams
Timothy Hay ....Alcoholic extract, 129 grams; sodic hydrate, 131 grams
Native Hay .....Alcoholic extract, 117 grams; sodic hydrate, 194 grams

from which I infer that it is not probable that the value of the sodic hydrate extract in the alfalfa and saltbush is dependent upon the proteid content of the hays, but due to other compounds. In passing this subject, it may be noted that the proteids soluble in alcohol have as high or higher coefficients of digestion than those soluble in the sodic hydrate. The proteids soluble in hydric chlorid are less in amount and have lower coefficients of digestion than those soluble in alcohol or sodic hydrate.

§235. There appear now good reasons why the native and timothy hays might have repaid us for making a comparative study of them, even though the timothy has already been studied in this sense, at least to some extent, and the native hay could give results of a general value only.

§236. The native hay and corn fodder are apparently much more similar than any other two of the six; they gave the same

feeding results and both effected it at a comparatively small cost of energy. This is particularly the case with the corn fodder, which produced a gain of 3½ pounds in the weight of the sheep receiving it on the minimum weight of dry matter digested and a minimum of energy, 4,940 grams of dry matter, 19.4 millions of calories, and a gain of 3½ pounds. Alfalfa produced a greater gain, but the sheep digested 7,734 grams of dry matter, appropriated 30.9 millions of calories and gained 9 pounds. The effect of poor fodders are best shown by comparison with these, as sorghum, for instance, the sheep digested 6,725 grams of dry matter, 25 millions calories, and lost 8½ pounds; as saltbush, they digested 7,351 grams of dry matter, 23.1 millions calories and lost 8½ pounds.

§237. The methoxyl group is present in all of these fodders, but it is not abundant and is digested to only a small extent, as indicated by our results, and whether it plays any part in determining the value of the fodder or not, is not apparent.

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COLORADO FODDERS

A STUDY OF COMPARATIVE VALUES
BASED ON BULLETIN 124

—BY—

W. P. HEADDEN.

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A STUDY OF RELATIVE VALUES OF COLORADO FODDERS

A Continuation of Studies in Bulletins 39 and 93.

By W. P. Headden.

§ 1. The scientific feeder and student of animal nutrition has, for the past forty-five or fifty years, been accustomed to divide fodders into certain big groups to which different names have been applied and now the veriest tyro can talk very glibly of proteids and carbohydrates, but, after all, the practical man, and even our scientific friends, do not adhere tenaciously to the data indicated by the results of the calculations based on the analytical data, but adopt the plainer and easier way of judging the value of a fodder by the effect it produces. A grass may have, according to the results obtained by the analyst, an admirable composition, but if animals will not eat it, its good composition goes for nothing, or if they eat it and constantly lose in weight, the excellent analytic results are of no value. Facts similar to these are met with, sometimes in this extreme form, sometimes in a milder form.

§ 2. Hays made from different plants vary in quality, i. e., in their fitness to be used as fodders and in their fattening qualities. These differences are very great even when no individual idiosyncrasies of the animals fed can be appealed to to explain away the facts. In a bulletin published by the Colorado Experiment Station we have made an attempt to explain the reasons for these differences. It appears from this work that the extract obtained by boiling the fodder repeatedly with 80 per cent alcohol, is the most important part of the fodder; it contains a large, if not the largest, part of the nitrogenous substances and very large quantities of other matters.

§ 3. It is pointed out that water alone will extract as much as 40 per cent of alfalfa hay, This hay is easily damaged by rain. The explanation offered is the ready solubility of so large a portion of the hay.

§ 4. The alcoholic extract is itself highly digestible. This is true, too, of the nitrogenous matters contained in it. It is further demonstrated that this alcoholic extract furnishes more energy to the animal than any other portion of the fodder. This is true in each of the six fodders whose composition is presented.

§ 5. It is shown that the fodders yield extracts to muriatic acid, also to a solution of caustic soda, which vary in value in the different fodders. In some fodders, the former extract, but in others the latter, has the greater value. In alfalfa, the portion removed by the caustic soda, but in the Colorado native hay that removed by the muriatic acid is the more valuable portion. To the most of us, however, the surprising feature is the high value possessed by what is designated as residue or cellulose, the portion left after treating the hay with alcohol, muriatic acid, caustic soda and chlorin. It would seem that there would be but little or nothing remaining of a hay after being treated with these chemicals in the succession given, still

it is shown that one-half or more of this residue is digested by sheep in the case of alfalfa hay, native hay and corn fodder, but less than one-half in the case of timothy hay and sorghum fodder, and even less than one-third in the case of one of our native saltbushes which was studied with the purpose of seeing whether it might be used as a fodder. This residue or cellulose is not only digested by the animals to a large extent, over one-half of it being digested in the fodders which gave good feeding results, but the energy which it yielded to the animal was large, in the corn fodder, the alcoholic extract alone furnished more energy.

§ 6. We have heard so much about proteids and their value that we have come to think of these substances as the most important portions of a fodder. This is largely because they are not as abundant as some other kinds of substance and may be present in a fodder in such small quantities that the feeder may have to purchase them in order to obtain results which he desires. This bulletin does not in any way lower the value to be placed on the nitrogenous portions of the fodder, but it shows that the value of a fodder depends largely upon the character of its other constituents. The writer shows that two lots of sheep, one receiving alfalfa hay, the other salt bush hay, were digesting very large and nearly the same amounts of porteids but very different amounts of other substances included under the general term of carbohydrates, particularly was this true of the cellulose which represents those carbohydrates which were capable of resisting the action of the several chemicals previously named. The sheep receiving alfalfa gained nine pounds in live weight during the five days elapsing between he two weighings, and those receiving saltbush hay lost eight and one-half pounds. Attention is called to this fact and in explanation, it is pointed out that the cause of loss in the latter case is not due to a lack of proteids, for the amount of this class of substances digested is nearly as large as in the former case. The question in regard to the relative value of the nitrogenous constituents of the fodders is suggested and while it is admitted that there may be a difference in this respect they are assumed to be equal, no data being at hand to justify any assertion to the contrary.

§ 7. The two lots of sheep digested approximately the same amounts of proteids and it is held that assuming them to have the same value in the two fodders, the explanation of gain in the one case and the loss in the other is not to be found in this part of the fodder and consequently we have to study the effects of the other constituents.

§ 8. The amount of the different extracts, their digestibility and their fuel values are taken as indicators of their respective values. It is acknowledged that a small amount of some therapeutically active substance might exert a very markedly disturbing action, but though this fact was known and looked for no indication is given that such effects were noticed. In fact, the statement is repeatedly made that the animals appeared comfortable and contented, that they chewed their cuds contentedly or equivalent expressions. This assumption re-

garding the relative value of the proteids in the two fodders, which, by the way, have high coefficients of digestion, 72.99 in the alfalfa, and 66.2 in the saltbush, and the probable absence of any deleterious substances having been made, there is left as the next important group, the substances represented by the nitrogen-free extract, which is divided into several parts, each of which, however, contains some proteids, except possibly the chlorin extract and the cellulose or residue.

§ 9. The alcoholic extract represents these nitrogen-free substances in a large measure, but contains at the same time a large portion of the nitrogenous matter of the plant; the extract obtained by exhausting the hays with cold water and hot water with subsequent addition of malt extract are, taken together, of some moment, as they represent in round numbers one-tenth of the air-dried hay and usually show from fair to good coefficients of digestion; it is also true that the portion removed by treating the portion remaining after boiling with one per cent caustic soda, with chlorin, again heating with caustic soda and subsequently with a solution of sulfurous acid, may amount to a noticeable quantity, but its coefficient of digestion is always low, often zero. So that the carbohydrates are practically divided into four parts, those soluble in alcohol, those soluble in muriatic acid, those soluble in caustic soda and those which are insoluble. The value of this class of substance has always been recognized but in this work it is emphasized, particularly in the comparison of these two fodders, the alfalfa hay and saltbush hay. In the former they are not only abundant in the alcoholic extract but they are also highly digestible; but this is not true of the other three important parts of the saltbush hay, i. e., the parts soluble in muriatic acid, caustic soda and that which is insoluble in any of the solvents used; these parts of alfalfa hay have high coefficients of digestion and the sheep gained in weight, but in the case of the saltbush hay they have low coefficients of digestion and the sheep lost in weight.

§ 10. The great difference between these two fodders, alfalfa, an excellent one, and saltbush, a very poor one, lies in the character of the carbohydrates present in the two plants. While the proteids may be different, they are abundant in both plants and are both highly digestible. In this respect these two fodders are much more nearly alike than any other two fodders studied. This is fortunate for in regard to the quantity of proteids present and their digestibility, the hays are similar but the carbohydrates in three of the important portions of the plants are very unlike, though abundant in both plants, They are very difficultly digestible in the saltbush and required so much energy to effect their digestion that there was not enough appropriated from the fodder to do the work and carry on the animal functions without using some of that already stored in the body, therefore the animals lost flesh.

§ 11. The large amount of proteids digested in each instance and their high coefficients of digestion are tacitly assumed to be presumptive evidence that they yielded more energy to the animals than

was necessary to do the work of fitting them for assimilation by the system. Their similarity in quantity and coefficients of digestibility is considered fortunate as practically eliminating the question of their influence, the difference of the effects of these food elements not being great enough to materially change the effects of the other elements in consideration.

§ 12. The carbohydrates are not divided into classes except to the extent and in the manner explained in the following: The familiar members of this class, glucose and cane sugar, do not occur in large quantities in ordinary hays, but they are wholly digestible and where present constitute a valuable factor in the fodder. The saltbush contains more of these two sugars taken together than the alfalfa does, so if we consider the value of the saltbush as depending on the quantity of these two substances alone it should be better than the alfalfa, but this is not the case. The same is true in regard to two others of these carbohydrates, the gums and starch which are more abundant in the saltbush than in the alfalfa. The frame work and tissues of the plants themselves very largely belong to this class of substances, carbohydrates, and though we do not know the definite composition of some of these plant constituents, they can be changed, in part at least, so as to yield compounds whose composition is known and the yield of such compounds by the different hays when treated with different agents has been made use of to establish the differences in the fodders themselves. The sugars already named are only two well-known members of this class of substances which include a number of others not so commonly known to the general public. Some of these related substances yield one and some another sugar under the action of certain agents. By taking advantage of these properties, the following differences between the alfalfa and the saltbush have been established.

§ 13. It should be kept in mind that the object had in view in doing this work, was not primarily to establish the value of the fodders but to find out, if possible, why one gives goods results and the other poor ones. There is a kind of sugar to which the name wood-sugar has been given because it is formed when wood is subjected to a certain treatment. The sugar or the material from which it can be made, is capable of being determined with approximate accuracy by methods which have been worked out. In this way, it is shown that certain carbohydrates are present in that portion of the alfalfa soluble in alcohol which are wholly absent from the saltbush and these substances in the alfalfa are easily digestible. A similar carbohydrate is present in the muriatic acid extract of the alfalfa. There is, however, twice as much of this substance in the corresponding extract of the saltbush, but that found in the alfalfa is wholly digestible, while that in the saltbush is wholly indigestible; this may simply mean that but little of this portion of the hay is changed while passing through the alimentary tract and fecal matter capable of yielding this substance is present in the dung in such large quantities that there is more in the feces than was taken

into the animal as food. But here is a big difference, one which appears to be too great to be explained away by unavoidable errors in the work. The individual extracts in the different fodders were examined in this way and also the residues or the cellulose that resulted from the treatment adopted. In this connection, it is shown, the carbohydrates yielding this substance taken as a common measure, that these residues or celluloses are very different in their values. The caustic soda does not, it is true, dissolve very much of this class of substances, but the alfalfa yields about one-third as much as the saltbush, of which but a small part was digested, while that dissolved out of the saltbush is not only nearly three times as great but a very much larger proportion of it serves as food. The most striking difference in the character of these carbohydrates is presented by the residues obtained which ought to be approximately pure cellulose and consequently have nearly the same value. This, however, is not at all the case, for this portion of the alfalfa has almost three times the value of that of the saltbush if the coefficient of digestion is a proper guide in judging of their value. A little later we will find that this fact is shown by another method, establishing with a considerable degree of certainty, that there is a very great difference in the character of this portion of the respective fodders.

§ 14. The muriatic acid extract of the alfalfa contains, as previously stated, less of the substance corresponding to the wood sugar than the saltbush, but the alfalfa yields a sugar that may also be obtained from milk sugar and which is not present in the saltbush, or if present at all, constitutes a very small portion of the fodder. This sugar is apparently very digestible. The coefficient obtained for all the sugar found in the muriatic acid extract which included both kinds of sugar mentioned is high. There is but little of the material corresponding to the wood sugar present in this portion of the alfalfa, but there is some. The alfalfa and the saltbush belong to entirely different orders of plants, and the pea family, to which the alfalfa belongs, yields this sugar which may be derived from the sugar of milk, while the saltbush and ordinary hays yield but little of this, yielding wood sugar in its stead.

§ 15. The energy relations, i. e., the amount of heat gotten out of the fodder by the animals and also out of the different parts or extracts of the fodders were determined and the fodders were found to be very different in this respect, as well as in those respects already pointed out. Furthermore, it was shown that the same amounts of energy appropriated from different fodders produce different results, measured by the loss or gain in the live weight of the animal, or we may say that the efficiency of the energy varies in different fodders.

§ 16. As we have, in the main, taken alfalfa and the saltbush for our purpose so far, we will continue to use them though we will have to take up the grasses later.

§ 17. We have previously related that it was found that the extract obtained by treating the fodders with alcohol appeared to be

the most important portion in all cases, though they showed a great difference in value in the cases of the different fodders. In these, the alfalfa and the saltbush, the amounts of alcoholic extract digested by the lots of sheep in five days chance to be the same, but the energy appropriated by the lot which received alfalfa was very much greater, nearly twice as great as that appropriated by the lot that received saltbush. It will be recalled that it was stated that there was so big a difference in the character of the carbohydrates of these two plants that it could not in any way be ascribed to errors of manipulation. We here find, by another method, that the alcoholic extract of the saltbush yielded only a little more than one-half of the energy that the corresponding alfalfa extract yielded. This difference might be due to the different quantities of proteids in the two extracts, but it is not, provided that they have even approximately the same value in the two fodders, for they received and digested a larger quantity of proteids in the form of saltbush hay than they did as alfalfa hay, showing that, viewed from the standpoint of fuel value, the difference very probably lies in the character of the carbohydrates. While it is admitted that little is known of the character of the proteids dissolved out of these or any other fodders by alcohol, we have as good a guide for our judgment in this case as we have in others pertaining to the character of fodders, i. e., the animals digested not only a larger quantity of nitrogenous matter when fed on saltbush but assimilated a larger proportion of that that they received. We will not consider all of the extracts in this manner lest too many similar statements should obscure rather than emphasize the facts intended to be brought out, so we will only consider the muriatic acid extract and the residue or cellulose. The former, muriatic acid extract, furnished very much more digestible dry matter in the case of the saltbush than in that of the alfalfa, one-third more, but its coefficient of digestibility was materially lower, two-thirds that of the alfalfa, and we find the energy almost exactly one-half of the amount yielded in the case of alfalfa. The proteids in this extract of these two fodders were nearly the same, both in regard to their quantity and digesibility, showing again that the difference was probably due to the character of the carbohydrates. The only other and last big feature of these two fodders that we will mention will be the cellulose which, owing to the method of preparation, contains very little nitrogen, no ready formed sugars or subsances soluble in alcohol, water, muriatic acid, caustic sodic or removable by chlorin, in other words, the soluble substances and those portions of the woody tissue capable of being broken up and removed by these agents had already been eliminated and though this residue would appear to be of but little value as food for the animal, we find it always one of the first three portions in importance. We would probably, without definite knoweldge to the contrary, not only consider this portion of but little value, but would expect to find it of nearly equal value in all cases, which is no nearer the truth than the former. In these two cases, we find that over one-half of the alfalfa cellulose is digestible while less than three-tenths of the saltbush

cellulose can be digested by sheep, and further, while the sheep received a much larger amount of energy in the form of saltbush cellulose than in that of the alfalfa cellulose, they were able to utilize only two-thirds as much energy, again showing that it is the character of the carbohydrates, peculiar, perhaps, to each individual tribe of plants which determines its feeding value.

§ 18. We have now rapidly examined these fodders in their main features, the most interesting of which is the relation of the energy values. There may be many errors in our work and serious mistakes of judgment, but all of these can not obscure the fact that a smaller amount of energy consumed as alfalfa produced a bigger result than a larger one consumed in the form of saltbush. In order to make this clearer to the casual reader, I will state this result a little more fully. The sheep consumed forty-nine million units of energy as alfalfa hay and gained nine pounds; the same sheep under as favorable conditions as could be produced, consumed fifty-nine million units of energy as Saltbush and lost eight and one-half, a total difference of seventeen and one-half pounds of flesh. The repeated observation that the carbohydrates of the saltbush, whether in the form of cellulose or the other forms making up the whole structure of the hay, are more difficulty digestible than those of the alfalfa may be interpreted as indicating that the work necessary to prepare the carbohydrates for assimilation is so great that it cannot be accomplished by the digestive processes in the sheep, when the saltbush is the only fodder fed, except by using up energy stored in the body in the form of flesh, muscle or fat. The amount of energy supplied was more than abundant to have produced excellent results, had the sheep been able to set it free without the expenditure of too much energy previously stored in the form of flesh. In the case given, there were actually ten million more units of energy in the fodder consumed as saltbush than in that consumed as alfalfa, but the energy which the sheep appropriated from the saltbush was, in round numbers, eight millions less than that appropriated from the alfalfa.

§ 19. The amount of energy appropriated by the sheep with which this experiment was conducted was a little over twenty-three millions units, a quantity somewhat in excess of the amount appropriated from two other fodders on which each lot of sheep made a gain of three and one-half pounds. This indicates that the absolute amount of energy appropriated in the case of the saltbush was considerably more than would have sufficed to maintain the animals in the condition in which they were at the beginnig of the experiment, but the fact is that they each lost. The question in regard to the cause of this loss is answered above in that we suggest that not only this energy was used up, but as much more as corresponds to eight and one-half pounds of flesh, in converting these carbohydrates into proper food for the animals, in warming the excessive amount of water which this fodder caused the sheep to drink, and in maintaining the animal functions.

§ 20. We have so far presented the study of the two fodders, alfalfa and saltbush, only incidental mention having been made of the

other fodders studied, one of which was studied as fully as the two already mentioned, namely corn fodder. This fodder is one easily digested in the sense in which we have indicated that the saltbush is difficulty digestible. By this I mean that comparatively small amounts of heat are used in the work of preparing this fodder for assimilation. In this case, we have a little less than nineteen and a half million units of energy appropriated and each sheep gained, the lot making an aggregate gain of three and a half pounds. This is the smallest amount of heat on which an actual gain was made. This shows the relative efficiency of the energy in the corn fodder, as compared with saltbush. This relative efficiency of the corn fodder would appear to be much greater if compared to that of sorghum in which form the animals appropriated twenty-five million units of energy and lost 8½ pounds. The fuel or energy values of the various extracts of sorghum were not determined but the coefficients of digestion, especially for the two large and important divisions represented by the muriatic acid extract and the residue, cellulose, indicate a low digestibility of the carbohydrates. The proteids probably do not influence these results in any material way. The results obtained with sorghum, it having been fed alone, were surprisingly unfavorable. The large amount of heat used and the low coefficients of digestion found for the greater portion of the fodder indicates that it, like the saltbush, requires more work to bring it to an assimilable form than is an equivalent to the energy yielded by the fodder. In the case of sorghum, the alcoholic extract is abundant and has a high coefficient of digestion, due, very probably, to the fact that it is rich in the two sugars, glucose and cane sugar. I did not determine the fuel values of this or any other of the extracts made of the sorghum. The fuel value of the fodder itself is almost exactly the same as that of the saltbush, which is low, thirty-eight hundred units of energy against forty-two hundred in the corn fodder, the actual difference being three hundred and fifty units for each gram of dry hay.

§ 21. The three important portions of corn fodder are, the portion dissolved by eighty per cent. alcohol, the cellulose and the portion soluble in muriatic acid. These extracts, the alcohol and muriatic acid extracts, both have very high fuel values and are easily digestible. The residue or cellulose has a rather low fuel value but owing to its coefficient of digestion being high, it furnishes more energy than any other portion of the fodder, the alcoholic extract excepted.

§ 22. The deportment of the proteids in this fodder is very different from those of alfalfa. The greater portion of them being found in the caustic soda extract in the latter case, while the greater portion is found in the alcohol extract of the corn fodder. The cellulose of the saltbush proved to be much less efficient in furnishing energy to the animal than that of alfalfa, but in comparing the efficiency of the cellulose of corn fodder and alfalfa we find that that of corn fodder is the more efficient. The animals did not eat the stalk with the pith cellulose if they could avoid it, so the cellulose in this case does not include much of the pith cellulose, though it does include some.

§ 23. The amount of proteids in the corn fodder is comparatively small and their coefficient of digestion low, so that, whatever their distribution and importance, their influence cannot materially alter the general results obtained. The corn fodder cellulose is instructive because it has a rather lower fuel value than the other celluloses, but it has the highest coefficient of digestion of any of them.

§ 24. We have now presented a hay made from a member of the pea family, one of the goosefoot family and one from a very coarse grass, corn. We will next consider a mixture of small grasses, our native hay, and pure timothy.

§ 25. The native hay is a mixture of grasses and sedges with some rushes. We find this hay quite similar in composition to the corn fodder but a smaller proportion of the digestible proteids is taken into solution by alcohol than in the corn fodder. The combined amount of glucose and cane sugar is less, the wood is greater and the amount of still another sugar to which I have not specifically referred, but which is found in the caustic soda solution, is large enough to be considered separately. Such are the striking features of similarity in the composition of the two. The fuel values of the native hay were not studied in detail but the general results were that twenty-two and a quarter million units of energy appropriated as native hay proved to be exactly equivalent to nineteen and a half million units appropriated as corn fodder, if the gain in live weight is a correct standard by which to measure their effects.

§ 26. The native hay contains more proteids than the corn fodder but not as large a quantity as alfalfa hay, and they have a high coefficient of digestion. The carbohydrates are easily digestible but less so than those of either the alfalfa or corn fodder, and we find that it takes some three million units more of energy in the form of native hay than in the form of corn fodder to produce the same result, which is in perfect keeping with the lower coefficient of digestibility of the carbohydrates of the native hay.

§ 27. The timothy hay was studied to the same extent and in the same manner as the native hay. We find in it the same characteristics that we found in the native hay; a moderate amount of proteids, but their coefficient of digestion is somewhat lower. The nitrogenous constituents are soluble in eighty per cent alcohol to the extent of about one-third of the total amount present and this portion has a high coefficient of digestion.

§ 28. It seems to be generally true that the nitrogenous matters soluble in alcohol are readily digestible, for instance, we find that of this portion of alfalfa, eight-tenths is digestible; of the timothy hay, eight-tenths; of the saltbush, nearly nine-tenths; of the native hay, six-tenths, and of the corn fodder, six-tenths. I have stated that the alcoholic extract of a hay stands before any other portion in feeding value, as indicated by its amount, general coefficient of digestion and fuel value. The statement seems to hold to a large extent in regard to the proteids. No distinction being made between the amids and the proteids.

§ 29. We find that the fuel value of the timothy hay is quite high, about forty-four hundred heat units for each gram of dry matter but the sheep can only utilize this energy to an extent of a little less than one-half, and as a result we find that timothy hay does not furnish enough energy to make a good fodder. The lot of sheep receiving the timothy appropriated nearly seventeen and a half million units of energy and showed a slight loss in flesh.

§ 30. I have in this work refrained from analyzing the extracts further and have permitted some indefiniteness in the statement of the results, but I consider these points of no material importance to our present purpose. For instance, I have made no effort to determine whether the wood sugar, xylose, is made up wholly of this sugar, or is mixed with another closely related one. I have also considered it a matter of small importance in this study whether the reducing power found in the caustic soda extract is really due to wood-sugar or to one more nearly related to cane sugar. The fact has been established that in some hays, at least, the wood sugar is a mixture of two sugars and that the sugar present in the caustic soda solution probably does not belong to the group of wood sugars at all. These questions pertaining to the nearer chemical composition of the hays are interesting and important but for the purpose of this bulletin, I have deemed them omissible. The difference in the sugars from the alfalfa and other fodders has been mentioned, but this sugar, galactose, appears to be present in some of the other fodders, too, to a smaller extent.

§ 31. We find the difference between these fodders so marked, especially, in regard to the readiness with which they appear to yield their energy to the animals and the work which is necessary to prepare the food constituents for assimilation, that it does not appear strange that the fodders acually have very different feeding values.

Press Bulletin No. 29. January 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

COST OF COLORADO ROADS

E. B. HOUSE

The recent agitation upon the subject of good roads for Colorado has brought before the people many questions concerning the road system as it now exists, the amount of money now annually spent upon it, and the cost of a better system of highways.

To answer the question of present cost the following table is submitted, which gives a record of the money expended for road purposes since 1900:

Concerning the figures given in the table, it may be said that in May, 1906, a letter was sent to the county clerk of each county asking for the desired data and inclosing a blank to be filled out and returned to this station. Some of these letters brought prompt replies and some were never answered. To those counties who had not replied, letters were later sent to the county commissioners, asking for the same data.

Out of the fifty-nine counties in the state, replies were finally received from thirty-four containing the information asked for, three replied that no data was available, and from twenty-two no reply whatever could be obtained.

The fact that it was impossible to get complete figures from all the counties in the state is to be regretted.

The fact that it was not possible to get even a reply from many of the counties shows a condition of affairs which should be corrected.

Records and maps of the roads, together with the amount expended upon them, should be found in every county clerk's office and the clerk himself should be ever willing to furnish those figures for bulletin purposes. However, it is thought that enough data has been secured to furnish a good working basis.

COUNTY	Total No. of miles road	No of miles road on plains	No. miles road in mountains	MONEY EXPENDED					
				1900	1901	1902	1903	1904	1905
Adams	No rep	ly		$	$	$	$	$	$
Arapahoe	No data						1185.64	10908.10	7368.64
Archuleta	No rep	ly							
Baca	2½	2½				10.00	28.50	3.06	12.50
Bent	200		200	12000		15000	21000	15000	13000
Boulder	600	400	200	26975.54	30468.95	29190.08	31770.42	29795.11	29245.44
Chaffee	250.00	125	125	5000.00	5000.00	6000.00	6000.00	6000.00	6000.00
Cheyenne	All section lines			20.00	25.00	30.00	30.00	35.00	30.00
Clear Creek	150		150	9962.59	13978.34	15958.34	16001.17	16966.74	18582.73
Conejos	No rep	ly							
Costilla	Cannot	give	the in	formation as			ked for		
Custer	No rep	ly							
Delta	Nodata			No data					160.00
Denver			Nodata	asked for					
Dolores	75	25	50	1213.00	1105.00	2106.00	1308.00	1154.00	758.00
Douglas	No rep	ly							
Eagle	207	67	140	13986.47	7170.29	4095.71	8762.60	12274.26	8299.32
Elbert	No rep	ly							
El Paso	Nodata	on mileage		18413.59	16908.03	29434.93	19420.74	18635.55	18752.42
Fremont	4 to 500	250	200	1700.00	18500.00	2000.00	26000.00	23000.00	23500.00
Garfield	850	200	650	12190.45	12192.59	1309.49	11188.03	18282.50	20726.13
Gilpin	No rep	ly							
Grand	No rep	ly							
Gunnison	900	500	400	8205.16	1120.99	8851.40	7283.31	11840.39	9243.97
Hinsdale	90	200	70	1906.73	2426.35	1949.05	1407.30	1532.05	1819.85
Huerfano	No rep	ly							
Jefferson	Annual	appropriation		of 25	000	18500.00	18500.00	18500.00	18500.00
Kiowa	No rep	ly							
Kit Carson	95	95							
Lake	146		146	6000.00	6000.00	6000.00	6500.00	6000.00	6000.00
La Plata	No rep	ly							
Larimer	Nodata	on mileage		20830.27	21731.48	33621.46	50231.55	83076.54	81204.49
Las Animas	No rep	ly							
Lincoln	No rep	ly							
Logan	Nodata	on mileage		14870.85	18416.00	9006.02	3752.58	6372.48	8230.53
Mesa	No rep	ly							
Mineral	75		75	250.00	2500.00	2500.00	2500.00	2700.00	6500.00
Montezuma	350	200	150	3907.30	5689.25	5123.25	7306.69	5828.07	74.85
Montrose	No rep	ly							
Morgan	300	300		800.00	4332.80	7017.00	10630.00	10804.00	15115.89
Otero	800	800		6980.19	14764.12	24081.58	21524.99	33468.98	34207.63
Ouray	Nodata	on mileage				11451.57	15433.41	14920.26	12917.73
Park	No rep	ly							
Phillips	30½	30½	None	0	72.80	59.75	69.50	38.60	264.23
Pitkin	Nodata	on mileage		6806.90	6306.20	8161.89	5780.35	3979.53	3773.23
Prowers	200	200							29000.00
Pueblo	No rep	ly							
Rio Blanco	450	100	350	2554.36	2540.71	2830.36	3864.70	22.80	31.39
Rio Grande	290	240	60	3361.25	5654.36	5286.85	4044.50	8622.55	6206.32
Routt	No rep	ly							
Saguache	Nodata	on mileage		5000.00	5000.00	5000.00	5000.00	5000.00	6000.00
San Juan	No rep	ly							
San Miguel	353	000	550	13714.45	13010.92	15157.49	17552.54	14845.05	18681.72
Sedgwick	160	160							836.04
Summit	No rep	ly							
Teller	195		195	5422.98	11175.33	13024.85	5751.27	8924.67	10468.84
Washington	No rep	ly							
Weld	2000	2000		25137.72	30961.91	34134.51	36917.34	53000.44	69545.03
Yuma	Nodata	on mileage		748.50	616.61	995.56	1259.14	2625.80	3858.28
Total	9227½	5726½	3501	265118.39	280912.68	340687.06	367654.15	438887.63	496457.45

From the table it will be seen that from the counties reporting there are 9,226 miles of county road in twenty-seven counties. This does not include the many miles of private road, which in time will all be taken over by the state or counties.

Figuring from this as a basis, the total mileage of county roads in the entire state is, in round numbers, 20,000 miles. Add to this the mileage of private roads, and some conception may be had of the tremendous mileage Colorado's road system represents.

Taking the twenty-seven counties making complete reports to this office, we find an expenditure

In 1900 of $203,918.19, which means ..... 22.12 per mile.
In 1901 of 217,118.68, which means ..... 23.53 per mile.
In 1902 of 259,437.30, which means ..... 28.14 per mile.
In 1903 of 282,229.79, which means ..... 30.59 per mile.
In 1904 of 319,826.73, which means ..... 34.67 per mile.
In 1905 of 375,003.51, which means ..... 40.64 per mile.

Using these figures as a basis, the total mileage of the state represents an expenditure

For 1900 of .....$442,400.
For 1901 of ..... 470,600.
For 1902 of ..... 562,800.
For 1903 of ..... 611,800.
For 1904 of ..... 693,400.
For 1905 of ..... 812,800.

In figuring the expenditure per mile, it will be noticed that it was necessary to omit such counties as El Paso, Larimer, Logan, etc., for the reason that they could not give the number of miles of road in their counties, although they were able to give the expenditures. As these counties have a large yearly expenditure, the above figures are low rather than high.

It will also be noted that there is a steady increase in the amount expended for road purposes each year. The amount spent in 1905 was nearly double that of 1900, thus showing the increased interest and desire of the people for better highways.

Press Bulletin No. 30. March, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE HOWARD SCALE

E. P. TAYLOR

Introductory.—Extensive injury by the Howard scale is being done in parts of the state. Its chief food plant being fruit trees, it is of especial interest to the horticultural industry. It is a close ally to the San Jose or Chinese scale, which, so far, is not reported to occur in Colorado.

The Howard scale has been previously reported in bulletins from Colorado and other states and notes given upon its habits and life history, but no experiments for its control have been undertaken before the work now reported.

The past year the writer had an opportunity to make observations upon the insect in its economic relations in the extensive orchards of Western Colorado, particularly in the Grand Valley, in Mesa County, where practical spraying by the most progressive growers was found already in practice.

Trees Attacked and Nature of Damage.—It is most common upon pear, prune, plum, and almond. The Bartlett is the most susceptible variety of pear grown in the Grand Valley. Silver prunes are quite often found encrusted, and almonds, though grown to a limited extent in Western Colorado, seem to be quits susceptible to its ravages. It is rather exceptional to find apples infested. Grimes Golden seems to be its favorite variety,, but Bailey Sweet, Ralls,, and Snow have been found slightly attacked. Peaches are practically exempt from it, though a few specimens have been taken upon trees growing near infested trees. It is probably native to the country, having lived originally upon wild trees or plants and found suitable food upon the fruit trees planted adjacent to them in later days.

Damage from the Howard scale results either in injury to the tree from the sapping of its life by the insect or in the unsightly pitting and discoloration of the fruit.

Description and Life History—Individual insects are of very minute size, being smaller than a pin head. They are of yellowish-orange color, covered by a pale grayish scale secretion. For the greater part of the insect's life it is motionless upon the bark or fruit. The winter is passed in an immature stage. In the spring, winged males appear, and early in the summer young insects are hatched from eggs laid beneath the female scale covering. These crawl about for a short time, finally settling down, the females to remain motionless for the rest of their lives.

Slightly infested trees will exhibit only inconspicuous grayish dots. Badly infested trees have a grayish appearance over their bark, much as if a layer of ashes covered the tree. When rubbed, this gives the surface a greasy or buttery appearance, caused by the crushing of the bodies of myriads of the yellow parasites hidden under the scales.

Spraying Experiments In Mesa County.—The principal spraying tests were conducted in the orchard of Mr. Ray D. Garrison at Fruitvale, east of Grand Junction, in an orchard of about 200 pear trees of varying degrees of infestation and otherwise admirably suited for the experiment. The spraying here was done upon April 3, 5, and 6, just before the opening of the buds of the pear.

Of the insecticides tested, the lime and sulfur sprays proved to be superior from the standpoint of effectiveness and cost. They are to be recommended to the use of fruit growers as the most valuable spring spray for trees still dormant. Besides being a contact insecticide of high value against other fruit tree insects, it is also valuable as a fungicide.

Lime-Sulfur Washes.—The orchardman may either prepare his lime-sulfur wash by cooking, or he may secure upon the market concentrated commercial lime and sulfur solutions, which need only be diluted with cold water to be ready to apply. The "Rex" lime-sulfur is a product of this class. In its undiluted form it is a clear reddish liquid. To equal in strength the home-made lime and sulfur mixture, one part "Rex" must be diluted with from eight to eleven parts of water. This makes the cost of the "Rex" material from two to three times as great as the standard lime and sulfur wash, but saves the cost and inconvenience of boiling the spray. Last spring the 30,000 pounds of "Rex" concentrate secured by a local fruit growers' association at Grand Junction gave satisfaction to the growers using it. In the experiments at the Garrison orchard it gave almost as good results as the standard lime-sulfur mixture. The counts of infested pears at picking time gave for "Rex," diluted 1 to 8 with cold water, but 2.8 per cent infested, as compared with .6 per cent infested from the lime-sulfur boiled at the orchard. Trees left unsprayed for com-

parison gave 96.1 per cent of the pears rendered unfit for market on account of the "scaly" appearance. Milk of lime should be added when "Rex" is used. About 15 pounds lime per 50 gallons of spray will whiten the mixture and enable the sprayer to see when the bark is being completely covered.

Directions for Preparing the Standard Lime-Sulfur Wash.—The following formula and brief description of the preparation of a small amount of the standard lime-sulfur wash recommended for the Howard scale is given:

FORMULA		
	Quick or Lump Lime	15lb
	Flour of Flowers of Sulfur	15lb
	Water	50gal.

To prepare 50 gallons of spray, place 10 gallons of water in a cooking vessel. While the water is being heated by a good fire, mix in a separate vessel 15 pounds sulfur with enough water to form a thin paste. Add this sulfur paste to the water in the cooking vessel and bring the mixture to a temperature just below the boiling point. Now add 15 pounds good lump lime. A violent slaking will at once take place. Keep cold water at hand, adding, if necessary, to prevent the mixture from boiling over the sides of the cooking vessel or to keep the mixture from becoming too thick. After the slaking of the lime has ceased, keep the mixture steadily boiling forty-five minutes, stirring almost constantly, when it will be ready for dilution with hot or cold water to make 50 gallons spray. It is then ready to be strained and applied.

Application.—Late spring will be the best time to spray. It should be borne in mind that the lime-sulfur wash is a caustic spray, designed only for dormant trees and not to be sprayed upon trees in foliage. The spraying should be delayed in the spring just long enough that all trees may be covered before the buds open. Buds may be sprayed with safety when some show green leaf rudiments, but should not be delayed until the cluster of buds separate into distinct fingers just before unfurling their first petals. More time and material should be allotted for lime and sulfur spraying than summer spraying against the codling moth. Thoroughness is the most important detail of the spraying operation. In using lime-sulfur washes every portion of the tree's bark, including the tips of the outer twigs, should be thoroughly coated. Spray should be directed upon the tree from all directions.

The apparatus used in preparing the wash will depend largely upon the amount of spray to be used. Prepared in a small way, the cooking may be done by an outdoor wood fire, and the cooking vessel may be a large iron kettle or a home-made vat, made with plank sides and sheet iron bottom and ends. Cooking lime-sulfur with steam is by far the simplest and best method. A jet of steam will cook and stir the mixture at the same time. Portable steam cookers, such as are

used for cooking stock food, are admirably adapted to the purpose. With these, the cooking is done within barrels. Such equipment is indispensable for preparing large amounts. Where very large quantities are to be used, a well-appointed cooking plant, fitted with steam engine and many cooking barrels, is necessary. Such a plant was built by Mr. Ed. Silva for use in the 240-acre orchard of Mr. John Ashenfelter at Montrose. The kind of spray pump used will also depend upon the size of the orchard and local conditions. A large number of gasoline power sprayers are in use in the Grand Valley for applying the mixture. Good, strong hand pumps give satisfaction where a fewer number of trees are to be treated. Long spray poles and long lengths of hose are desirable. Nozzles of larger aperture, producing coarse spray rather than a mist, are preferable for the lime-sulfur mixtures.

A well-appointed equipment will greatly lessen the cost and inconvenience attending its use. This is important, since lime-sulfur spraying has become an essential part in the routine of orchard work.

A fuller bulletin will be issued by the Experiment Station upon this subject, but as that will not be printed for some time, this brief summary is distributed for immediate use.

Press Bulletin No. 31. March 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

The Green Aphis and the Woolly Aphis of the Apple*

By C. P. GILLETTE

These two plant lice have become pests of the first importance in Colorado orchards. Wherever the green lice were seen curling the leaves of the apple trees in the fall, there the little shining black eggs may be found now upon the twigs. On March 8th and 9th, this year, I found these eggs just beginning to hatch in the orchards about Graund Junction, Palisade and Delta, Colorado. To keep this louse in check, the trees should be sprayed thoroughly just before the buds open. The later the spray can be made the better, provided it is made before the buds open enough so that the lice can crawl down among th opening leaves for protection. It would be better to spray a little early than to delay too long.

Spray to Use.—Probably the best spray to use, all things considered, is lime-sulfur mixture prepared as follows:

Good lump lime	30 pounds.
Flowers of sulfur	30 pounds.
Water	100 gallons.

Add enough warm water to the lime to slake it, and while it is slaking add the full amount of sulfur, which first should be thoroughly moistened with hot water. Sulfur will mix easily into the water if a little soap is added. Keep the lime and sulfur boiling vigorously over a fire, or by means of a jet of steam, for about 45 minutes, or until the liquid is of a deep brick red color. Add water when necessary to keep the mixture quite thin while cooking. When the cooking

**Aphis pomi* De G. and *Schizoneura lanigera* Hausm.

is finished, add enough water, cold or hot, to make the 100 gallons of spray, and pass the whole through a strainer or a piece of gunny sacking to take out all lumps that will clog the spraying nozzle, and apply at once to the trees in the form of a spray. "Rex" lime-sulfur may be used instead of the home-made article, putting 1 gallon of the Rex in 8 to 10 gallons of water. If material is not at hand for the lime-sulfur spray, kerosene emulsion that is about one-tenth kerosene, or one of the fish oil or whale oil soaps in the proportion of 1 pound of soap to 6 gallons of water may be used instead. A tobacco decoction may also be used, if preferred, in the proportion of 1 pound of the tobacco to each 3 or 4 gallns of water. Steep the tobacco for an hour, at least, before using, and see that the dust is not mostly sand.

The above sprays, except the last are for use while the trees are dormant (before the buds are open) only.

The Woolly Aphis has survived the winter in large numbers and is just beginning to secrete its cottony covering in the warmer sections of the state. All infested orchards should be sprayed at once, to destroy the lice on the tops. The whole trunk should be drenched, and it will be well to wet the ground about the crowns of the trees also, as here is where a great many of the lice spend the winter.

Use any of the sprays recommended above for Green Aphis, and apply with a good deal of force, so as to wet through any secretion that may have formed upon the bodies of the lice for their protection. While these spring treatments may be all that are needed, it is not unlikely that summer treatments may also be needed in many instances. In this case remember that the lime-sulfur mixture is for dormant trees only. The other sprays may be used after the trees are in full leaf in the following proportions: Kerosene emulsion that is one-fifteenth kerosene; fish oil and whale oil soaps in the proportion of 1 pound to 8 gallons of water, and tobacco decoction in the proportion of 1 pound to 4 gallons of water.

In all cases spray thoroughly and forcibly, and for the Green Aphis direct the spray chiefly from below.

By spraying early you will also avoid killing many of the lady beetles and other enemies of the lice that are killed with the lice in the later treatments.

Communicate freely with the Experiment Station whenever troubled with insect pests and send specimens when possible.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

The Locust Borer (*Cyllene robiniae* Forst)*

By C. P. GILLETTE

In July last year Mr. W. G. M. Stone, president State Forestry Association, called my attention to badly bored locust trees in two or three places in the city of Denver. This is a most serious enemy to black locust trees and is likely to kill all the trees in a city like Denver if it is allowed to pursue its natural course without hindrance. Mr. Stone cut down one of the badly infested trees about five inches in diameter, and had four feet of the body sent to me at the Experiment Station at Fort Collins, that the borer might be bred to maturity for the determination of the particular species that it might be. From this stick I bred ten adult beetles of this well-known locust borer of the Eastern States. So far as I can learn, this is the first record of this enemy to the locust in Colorado, and if prompt action is taken by the city authorities and county horticultural inspectors, and by all who have locust trees upon their lawns, it is possible that its injuries may be kept in check, if the action is prompt.

Appearance and habits of the borer.—The fully grown insect in its breeding stage is a dark brown beetle from one-haif to nearly three-fourths of an inch in length and with eight or ten narrow, but conspicuous, golden yellow stripes crossing the body above. These beetles, which might easily be mistaken for wasps, have the habit of collecting about golden rod and other yellow flowers during August and September, and it is at this time that they are also visiting the

* Bulletin 58, part 1, Bureau of Entomology, U. S. Department of Agriculture, by Dr. A. D. Hopkins, on this same insect, may be had by applying to the Bureau.

locust trees and depositing their white eggs in crevices of the bark anywhere upon the trunk and large branches. According to Dr. Hopkins, these eggs soon hatch, and the minute white grubs eat through into the inner bark and there remain, very small in size, during the winter. As soon as the steady warm weather of spring comes on, these grubs begin to bore into the hard wood and to increase in size. During this active feeding and growing period the dust or castings from these borers is pushed out to the surface, when it can be plainly seen, and where it accumulates in large quantities when a tree is badly infested. About the 1st day of July the borers are fully grown, and are white grubs about three-fourths of an inch in length. They then see to it that a burrow, large enough for them to pass through, is made to the surface of the bark. In this burrow the grub becomes inactive and passes into that mysterious insect stage known to entomologists as the pupa, or chrysalis, a resting stage, during which it is transformed from the blind, sluggish, worm-like grub to the beautifully decorated beetle with legs and wings and highly specialized organs for sight, touch and hearing, and for the reproductions of its kind. Its cycle of development is now complete, and in a few days or weeks the female beetle will be laying eggs for the next years crop of borers.

The Remedies.—It is doubtful if the application of insecticides to the surface of the tree can be of much use, and internal treatment, unless made in the burrows themselves, would be still less effective.

Dr. A. D. Hopkins, in the bulletin mentioned above, recommends cutting and burning all infested trees before July 1 each year; or, if it is desired to save the wood, submerge the trunks for two or three weeks after cutting to drown the borers. From November to May it will be sufficient to remove all the bark from the trunks and large branches and burn the remainder of the top. In fact, all cutting for posts or lumber should be during late fall or winter—October 1 to April 1.

It is to be hoped that all who are interested in retaining this valuable tree in Colorado will do what they can to exterminate this destructive borer. All trees suffering from the attacks of the borer should be reported promptly to Mr. W. G. M. Stone, State Forestry Association, Denver, Colo., to the County Horticultural Inspector, Denver, Colo., or to the Experiment Station, Fort Collins, Colo.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

Dairy Work for Plains Settlers

H M. COTTRELL

Thousands of families are coming to Colorado this spring to locate on farms. Many of them are locating in the dry land sections of the state, often on land on which a furrow has never been turned.

The methods of handling the soil, the varieties of seeds to use and the handling of the crops after seeding are entirely different from those found profitable in Eastern States. Experienced men who have farmed in two or more States and under widely different conditions do not expect to meet expenses for crop raising the first year while they are learning what methods and varieties are most profitable in a new location.

Many of our new settlers have a limited amount of capital, and a failure in crops this year would bring suffering to a large number and financial hardship to others.

To those settlers whose means are not sufficient to carry them through a year of crop failure and have sufficient left to grow a crop the second year, we would advise the breaking up of a small area only, not over 40 acres on a quarter section, and if money is quite limited, not over 20 acres.

Write to the Experiment Station, Fort Collins, Colorado, for advice as to the best methods of preparing the soil, the best crops to plant, varieties to use and best methods of treating the crops after seeding. This advice will be given gladly and freely.

The new settler should consult the successful farmers who are his neighbors, asking them the same questions that he asks the Experiment Station. Then utilizing the advice from his neighbors and

the Station, handle his 20 or 40 acres in such a way as to get the largest yield from them. He will learn more from cultivating this small area well than he will if he puts all the land he can into crops and is obliged to do the work poorly.

While learning how to raise profitable crops under his new conditions, the farmer will need an income to support his family. One of the best ways of securing this is by milking cows and selling the cream to a factory.

Range cows selected for milking qualities and fed on the native prairie pastures of Colorado alone will produce through the summer from $2 to $5 worth of milk per head a month. All the creameries pay cash at least once a month, and some of them pay daily. The farmer, if he cultivates a small area only, will have the help to milk from 10 to 15 cows, and these will give him a cash income of from $20 to $75 a month, depending on the number and quality of the cows milked.

Selling the cream to the creamery will require much less outlay for building and equipment than will be needed if butter is made on the farm, and will make the work much lighter for the housewife, whose work is already hard enough when starting in a new home.

The calves should be sold for veal as soon as old enough, and the work saved in not raising them by hand can be put on the crops and in making improvements.

The warm separator milk can be fed at a good profit to pigs and poultry, giving another source of cash income to the new settler.

Sorghum should be sown broadcast to be fed in the fall to keep up the flow of milk.

In selecting range cows for dairy work the grade short-horn has been usually found the most satisfactory. The cow should be selected for four dairy points—a good udder, prominent hip bones, a sharp bone at the top of the shoulder and large stomach capacity. The writer selected a carload of range cows along these lines. None of them had been fed grain and several had to be roped before they could be milked. These cows averaged over $40 per head the first year in cream sold to the creamery, and one cow with these points well developed produced $60 worth of cream the first year.

Press Bulletin No. 34. March 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

ACCLIMATED SEEDS

HINTS FOR NEW SETTLERS IN EASTERN COLORADO

By W. H. OLIN

So many settlers, coming from the humid regions of the central states into Eastern Colorado this spring, are bringing with them the seeds of the crops grown "back home," with which they hope to grow crops in a much drier region, that a word of caution is necessary.

Difference in altitude, amount of rainfall and general climatic conditions urges the writer to warn the new settler that past experience has shown that it will be hazardous to use any but acclimated seeds of such types of grain, forage and root crops as successful farmers of that locality have demonstrated show fairly good drouth resistant power.

Even with the most vital seed of established worth, in some seasons, lack of timely rains jeopardizes a profitable harvest. Last season one Eastern Colorado farmer seeded a drouth resistant strain of wheat, getting twenty-five bushels of good, sound wheat, and in an adjoining field, with the same seed bed preparation and after treatment, he seeded a wheat from another state of unknown drouth resistant power and got seven bushels per acre of inferior quality.

This is further illustrated in every crop grown on the eastern plains of Colorado. Seed, if you will, your choice imported grain in a seed block of an acre or less, but be sure to secure for the general field grain that is acclimated to semi-arid conditions. The following crops have proven to be reasonably certain in average years for this region:

GRAIN.

Corn.—(An early maturing corn should always be used.
White Australian Flint.
Swadley Dent, and
"Divide" Dent, or Colorado Yellow Dent.

Wheat.—For spring—
Kubanka Durum.
For fall seeding—
Turkey Red, or
Kharkov.

Barley.—(A bald barley or beardless type, seeded early.)

Rye.—One of the surest crops for hay or grain.

Oats.—This is not a reliable crop every year, but early types, as the Big Four, Kherson, and Sixty Day, acclimated to that region, have given very good harvest for several seasons.

Flax.—This is a new crop to Colorado, and for two years has done well, but its worth has not yet been fully proven. The writer would urge settlers not to seed this crop extensively until it has been more fully tested. If this seed is used, be sure to treat seed with formalin before seeding. The writer will send directions on request. Get Colorado-grown seed, if possible.

Emmer.—(Commonly called speltz.)—A drouth-resistant feed grain.

FORAGE.

Kaffir Corn, Dwarf Milo Maize,
Early Amber Sorghum, and
Proso, are good forage crops.

ROOTS.

Potatoes, where non-irrigated, or "Divide" seed is used, have proven the best root crop in recent years for the plains region.

Seek to grow that crop which will furnish feed, and plan to make some form of meat production the main product of the farm. Get the seed of a few well-tried crops and plan to seed them early, so the crop may get what early spring rains may chance to fall.

Rate of seeding is very important, since seeding too heavily takes up the limited amount of moisture in the ground, causing the whole crop to "fire burn." Do not seed as heavy as you did in the central or eastern states. The following table may be suggestive, but rate of seeding will vary with manner of seeding, size of seed and condition of seed bed, so no definite rule can be laid down. Do not seed broadcast, if you can possibly drill in the grain.

Rate of Seeding For Eastern Plains.

	lbs. per acre.
Grain crops.	
Wheat	30 to 50.
Wheat (Kubanka Durum	40 to 50.
Barley	35 to 50.
Oats	35 to 50.
Rye	30 to 40.
Emmer or Speltz	35 to 50.
Field peas	25 to 40.
Proso	6 to 12.
Forage crops.	
Sorghum	8 to 20.
(Varies with the method of seeding.)	
Alfalfa	15 to 25.
Meadow Fescue	15 to 25.
Brome Grass	15 to 25.
Vetches	18 to 30.

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FORT COLLINS, COLORADO

Wind-Breaks and Shelter Belts for the Plains

By B. O. LONGYEAR

Wind-breaks, as the term implies, are plantations of trees or similar plants intended to check the force of the wind. They may be used to lessen the drying effects of hot winds in summer to prevent injury or loss to fruit in autumn and to shut off the cold winds of winter from yards and buildings. Wind-breaks for the last purpose are usually called shelter-belts, and are often made several rods in width.

The location of the wind-break will, of course, depend on the direction of the prevailing winds. For general purposes the north and west sides of the area to be protected are the ones along which the trees are planted in most portions of this state. Shelter belts should be planted far enough from buildings so that drifting snows on the inner side will not be an inconvenience.

The simplest kind of wind-break is one formed by planting some one species of tree in a single, close row. If a tall-growing tree is used alone in this way there is a tendency for the trees to spindle up and in time the trunks lose their lower branches. Such an arrangement may do very well for a time, or where only partial checking of the winds' force is desired. But where more complete shelter from winds is desired, it is usually necessary to plant several rows of different species, so arranged that the low, dense growing kinds will fill in the places between the taller ones.

For the taller-growing tree in this region the common cottonwood may be used, setting them about eight feet apart for the outer or north and west rows. A second row of some denser-growing kind should be planted about eight feet from the first and as close as four feet in the row. For this purpose box elder is a suitable tree, except in dry situations, in which case the green ash is recommended. The trees in the third row may be planted the same as in the second row,

using a more compact-growing kind. The Russian golden willow is recommended for this purpose as a rapid grower. The Russian wild olive is a more compact tree of lower growth and is particularly desirable. White or American elm is also a suitable tree for the inner rows in many places, especially where a fair amount of moisture can be depended on.

In cases where the wind is exceptionally strong, it may be found necessary to plant a belt four or five rods wide, in order to secure complete protection. The outer two rows may consist of Russian olive, the third and fourth rows of black locust, the fifth and sixth rows of box elder or ash, the seventh and eighth rows of American elm, and the inner two or three rows of cottonwood or Carolina poplar, the rows being about eight feet apart. The golden Russian willow may be used in place of the elm, and honey locust may take the place of the black locust.

The ground should be prepared as carefully as for a crop of grain or sugar beets. Where the rows are to stand, the soil should be furrowed out each way by making a back furrow between each two rows. When harrowed, the land will slope each way toward the trees, thus tending to collect drifting snow where it is most needed.

The same care in planting should be taken that would be given in setting and orchard. Seedling trees, two years old, are better in most cases than large trees, as they will bear transplanting more readily, are easily handled, and the cost is much less than with the larger sizes. Trim off all broken and bruised roots with a sharp knife and cut back the tops to correspond. Set the trees an inch or two deeper than when in the nursery, and firm the soil about the roots.

As soon as planted, irrigate if water is available. If not, give a shallow cultivation to check surface evaporation from the soil.

Cultivation should be continued during the growing season, especially after each rainfall. This is particularly necessary on the plains or where water for irrigation can not be supplied. Such cultivation is calculated to keep a thin layer of fine, dry soil on the surface, which acts as a mulch to conserve moisture. Such care should be continued during the first three to five years, or until the trees shade the ground between the rows. A mulch of old straw at this time may be placed between the rows, and will assist the trees in keeping down grass and weeds.

Pruning is not desirable, unless it be so done as to cause a thicker growth. Thus in the case of the willow, many smaller stems may be secured by cutting out the main trunk a foot or so above the ground when four or five years old. In this way a single, or, better still, a double row of willows, closely planted, may be used as a hedge, which will also serve as a very effective wind-break.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

Preparation of Seed Bed

HINTS FOR THE PLAINS.

By W. H. OLIN

Crop conditions in Eastern Colorado are so different from crop conditions in the humid region that special attention should be called to them for the benefit of the new settler.

The very best system of tillage may fail to produce a crop some years, but proper soil management and use of acclimated seed adapted to prevailing conditions tend to render crop failures less frequent and harvests therefore more remunerative.

In the farming operations of many parts of Eastern Colorado, where irrigation can not be practiced, the amount of water available to plants is the "limiting condition of success," as Prof. Failyer calls it. Here is found abundance of cheap land, quite fertile, and water is the element that must be most carefully conserved to insure a crop. No rain water must be allowed to run to waste if possible to store it in the soil. Rains on the plains are usually quick dashing rains and the seed bed should be in such tilth that both upper soil and subsoil will readily absorb the water which falls during the crop season.

The preparation of the seed bed calls for careful plowing, harrowing and sub-surface packing.

Experience demonstrates that the preparation of the soil reservoir (seed bed) of good depth several months before seeding, the thorough culture of this ground before and after seeding, are essentials that very largely determine success in Eastern Colorado. Summer tillage conserves moisture while it renders more plant food available, keeps down weeds, and keeps soil in good tilth.

Preparing New Ground for Spring Seeding.—It is always a questionable practice to crop newly broken sod in a dry year. The sod usually contains but little moisture and the process of breaking causes one to loose an appreciable portion of it. Suggestive plan: Plow sod land not less than three nor more than five inches deep, turning sod down as flat as possible, and thus prevent its drying out too soon. Follow as closely with disc harrow as practicable, and this with some form of packer, either single or double roll. This will level the sod land above, and firm the soil in the lower portion of the furrow slice, restoring the capillarity where plowing has arrested it. This firmed under-surface soil is thus enabled to draw moisture from below and give good, normal root development. Follow up the packer with either an acme or a good smoothing harrow to produce a good earth mulch to arrest surface capillarity and check evaporation of soil moisture. Follow with the seeder. All small grain should be drilled in with a press wheeled drill, followed up with a good spike-toothed or smoothing harrow. It is almost necessary that all tillage operations on sod be with the furrows rather than across them to avoid tearing up the sod and drying out your seed bed. Do not seed broadcast. Make each tillage operation thorough—plowing, disking, firming, harrowing, and seeding.

When the new crop is up, cross harrow to prevent the formation of a crust and giving the young crop a cultivation. Follow up each rain with a good harrowing as long as character of crop will permit.

Early in June prepare seed bed for the fall and following spring's seeding. Try to hereafter seed only on ground which has been given "summer culture" treatment.

Remember that roots of all cultivated crops make their best growth when you provide:

A firm mellow
A warm mellow Soil well supplied with plant food.
A ventilated
A moist

Methods of farming which (a) conserve the moisture, (b) prepare a good seed bed, (c) reduce the evaporation to as near the minimum as possible, (d) use good vital acclimated seed, (e) employ a crop rotation which has stock foods prominent, contain at least one money crop, (f) and practice thorough tillage of the ground, often tide the farmer over bad years and insure his success in good years.

Press Bulletin No. 37. March, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

POTATOES ON THE PLAINS

SUGGESTIONS TO NEW SETTLERS

E. R. BENNETT

Where potatoes can be grown in this State they have proven one of the most valuable of the farm crops. However, little investigation has so far been made of the methods of culture that are best adapted to the conditions under which potatoes must be grown on the unirrigated lands of Eastern Colorado. Some very good crops of potatoes have been grown in this section in the past year or two, and it is thought possible that considerable acreages may be planted this year.

The methods of growing employed and the best varieties to plant are necessarily different from those used in the irrigated districts, so a word of advice to the new comers may be timely.

While it is advisable for every farmer to plant potatoes enough for the use of the family, we would not advise those inexperienced in the business to plant a large acreage at first. An acre or two, if successful, will more than supply the family needs, and, if unsuccessful, comparatively little will be lost.

Varieties and Seed.—One of the first requisites for success in growing potatoes on the plains is to get seed that is adapted to the conditions. Probably the best is that which has been grown under similar conditions for several generations. If that is not to be had, seed from the Arkansas divide (Elizabeth) country, or even from Dakota, Minnesota ,or Wisconsin will do. Seed from the irrigated lands should not be used.

Usually the early part of the season suffers less from drought than the latter; therefore, the early maturing varieties are generally

better for this purpose than the larger late potatoes. Early Ohio and Rose Seedling have been grown in this State with considerable success in the past and are probably safer to use than some of the common Eastern varieties.

Soils—Potatoes are grown on nearly all kinds of soils, but the lighter soils that will hold moisture are generally to be preferred. Land that has been cultivated should be selected in preference to raw land.

Preparation of the Land.—Plow the land to a good depth when in good condition to work as early in spring as possible. Harrow the land as fast as plowed to form a soil mulch and prevent loss of moisture by evaporation. From the time plowing is done till planting time, the land should be frequently harrowed. If rains come, the land should be harrowed as soon after the rain as the land can be worked without puddling the soil.

Planting.—In most cases the earlier the planting can be done without danger of early frosts hurting the vines, the better. When it is possible to do so, use a machine for planting, for by so doing the seed is put down into moist soil, while hand work is apt to leave seed covered with loose, dry soil, in which case the seed will be delayed in coming up and a poor stand result. If the seed is planted deep (not less than five or six inches), this trouble will be to a certain extent avoided. If machines for planting are not available, the hand potato planters used in the East will do the work fairly well.

With the limited amount of moisture that is available for the crop, the plants will do better if planted at a greater distance apart than is usually practiced. If the hand planter is to be used, the field can be marked out as for corn and planted in rows both ways. If the machine is used, rows from forty inches to four feet apart with hills twenty inches to two feet apart in the row will probably give the best results.

Cultivation.—After the potatoes are planted, the success or failure of the crop will, to a large extent, depend upon the cultivation given.

The first cultivation should be given soon after potatoes are planted, before the plants are out of the ground. Set the cultivator to run as deeply as possible to loosen and aerate the soil. The cultivator should be immediately followed by the harrow to smooth the surface and re-establish the soil mulch. After the potatoes are up, frequent shallow cultivation should be given till the vines become too large to work.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

GRASSHOPPERS UPON THE PLAINS

BY C. P. GILLETTE

The western plains have long been noted for their hordes of grasshoppers. The reputation is chiefly due to the great swarms of the "Destructive" or "Rocky Mountain Locust" that used to fly out from the mountains in numbers sufficient to destroy all crops in a few hours, wherever they stopped. This pest is no longer to be feared in Colorado, but there are several species of locusts (grasshoppers) that are present every year and often in destructive numbers. The habits and remedies for the most of these may be given in a general way as follows:

Life History.—During the fall months the female locusts deposit their eggs in little pockets, an inch to an inch and a half deep, in the ground. The eggs are found in largest numbers along road sides, ditch banks and the borders of fields. They hatch about as soon as green vegetation starts enough to give the little hoppers plenty of tender, nutritious food.

If plenty of food is at hand, the little grasshoppers do not wander far from the place of hatching for a few days, and their presence may be noticed by the perforated and ragged leaves of weeds as well as cultivated plants where they are feeding.

By the middle of July, a few of these locusts will have wings, whch means they are fully grown, but few, if any, eggs will be deposited before the middle or latter part of August. Very soon after a female has laid her eggs she dies, and there are some of the later individuals that do not finish egg laying until they are killed by the cold, freezing nights late in November. There is but one generation or round of development of the locusts in a year.

REMEDIES.

Destruction of Eggs.—The eggs of locusts are very soon killed by being exposed to the dry air and sunshine of Colorado, so if it is known that there are many of the eggs in meadows, alfalfa fields, along road sides or ditch banks, it is an excellent plan to plow or thoroughly harrow the infested ground during late fall, winter, or early spring. It will pay well to harrow the alfalfa just because of the increased crop of hay that will result, even if there are no locust eggs.

Destroying the Locusts.—The little hoppers, when very abundant about the border of the fields or along ditch banks, can be largely killed by a thorough spraying with arsenate of lead, 3 pounds to 50 gallons of water, or Paris green, 1-2 pound to 50 gallons, as for other insects. A narrow strip, not to exceed a rod in width, sprayed early in spring, would not endanger stock eating the hay later, but care should be used not to put stock upon sprayed areas too soon.

Where straw is available, it may be spread lightly over ditch banks and other places where the hoppers are abundant and be burned. In gardens and among potatoes and other vegetables poisoned bran can often be used with success. Mix 1 pound of Paris green with about 40 pounds of bran, add just water enough to moisten the whole, and then sow it broadcast where the hoppers are most numerous. If this poison is used, care must be taken to keep chickens and other domestic animals from the poison for some time.

One of the simplest and often a very effectual remedy is to grow plenty of chickens or turkeys to range over the infested grounds. Wherever coyotes abound, however, precautions must be taken to protect turkeys and chickens at night. Turkeys are very profitable, if raised with proper care, as they protect the crops from destruction, forage nearly their whole living, and sell at a high price in the fall or winter.

Hopper "dozers" or pans are also very successful where they can be used. Anyone wishing directions for making a good hopper pan should write the experiment station for a copy of Bulletin No. 112.

I shall always be glad to receive inquiries concerning insects that are doing damage in any part of the State. Send specimens of the insects when possible, with samples of their injuries.

Press Bulletin No. 39, March, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

Summer Culture to Conserve Moisture

HINTS FOR PLAINS SETTLERS

By W. H. OLIN

Many hundred farmers, unfamiliar with the soil and climatic conditions of our eastern plains, are this year coming to make homes on 160-acre farms in Eastern Colorado in regions where crops have not been generally grown. Many of these settlers have but a limited amount of money and can not afford a crop failure. It is to be feared that this spring crops will be only partially successful, since many of them are farming as they did "back home," and are not using drouth-resistant crops of demonstrated value in their farming operations. This timely suggestion is sent out to prevent crop failure in fall seeding. Preparation of seed bed is the most important thing in farming the non-irrigated lands, and as soon as spring crops are in, the new settler should plow and cultivate his field he expects to seed to fall crops, or the following spring's grain.

Summer culture is an essential of the Eastern Colorado farmer's success. The French found some centuries ago that "manœuvering" the land—causing the particles of earth to change place by tillage—made it more productive. Experiments now show that summer tillage in our semi-arid lands has an added value—it conserves the moisture, while it renders more plant food available. Good results have been obtained in Eastern Washington, Eastern Oregon, Utah, and many sections of Colorado from summer culture of the land every other season. It has been found that in this way sufficient moisture can be stored from the year's rainfall to mature a crop in many localities.

After the snows of winter have melted in the spring, plow the ground at least seven or eight inches deep. With disc harrow, corrugated roller, imperial pulverizer, or packer, level and firm this

ground as soon after plowing as possible, at least not later than each half day, and follow up with smoothing harrow to establish the earth mulch to check evaporation. This mulch must not be too fine, as the winds of the plains will tend to rift the soil or blow the earth mulch entirely away. If possible, stir the surface soil with a good spike-tooth or acme harrow several times through the summer from two to four inches deep. Follow every summer rain with a good harrowing of this "summer cultured" ground, preventing the formation of a crust at the surface. Keep this ground clean—free from weeds.

Ground that has been well cultivated for several years will produce two crops in succession and can be given summer culture the third year. In this way it is possible to grow two crops in three years on well-tilled soil. If a farmer expects to cultivate 80 acres, he should divide it into two crop divisions—cropping 40 acres the first year and giving summer culture to the other 40 acres. This gives him a crop on one half his land each year while he is storing up moisture in the soil reservoir of the other half to make the next year's crop. A farmer on the non-irrigated lands in Weld County last season, after seeding his spring crop, at once prepared his fall wheat seed bed—150 acres. The writer visited his field early in July and found his seed bed in a fine mellow, moist, condition for seeding. Just a few miles from this careful farmer's ranch was a 500-acre field which had been simply plowed and left in that condition to dry out and become hard. Although an inch of rain had fallen the week previous, the writer found the soil in this field in very poor mechanical condition—dry and hard. This clearly shows how not to do. Farmer No. 1 now has a most promising field of wheat and will undoubtedly be rewarded with a satisfactory harvest.

One of the writer's correspondents, living ten miles south of Akron, Colo., has practiced summer culture for several years. He reports that in the fall, when he seeds his summer cultured land, he often finds from three to five feet of moisture.

The writer knows that this method of summer culture has been practiced in some parts of California for upwards of forty years with satisfactory results.

Use every practical method you can to conserve the moisture. Summer culture keeps the ground in good tilth, keeps down weeds, renders the plant food easily available for the next year's crop, while it stores up the moisture so necessary to the plant in assimilating its food.

Press Bulletin No. 40. April, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

SEEDING FIELD PEAS

By W. H. OLIN

The field pea is a valuable annual legume for both the stock and the soil of the farm. It was grown in Canada many years before it was introduced into the United States. For this reason all kinds of field peas on this side the line are usually spoken of as "Canada Field Peas." It has only been within the last few years that farmers of Colorado have realized the value of this crop to the farm.

CLIMATE AND SOIL REQUIREMENTS—Peas do best in a cool, moist climate, where cool nights prevail. Many mountain valleys in the Rocky Mountain region seem to be peculiarly adapted to the field pea culture. By seeding early in spring, so blossoms and pods may form before the hot summer days come, this crop can be grown much farther south than is generally accorded to it by agricultural writers. Early seeding is really desirable in all sections of the United States where grown, since this crop is quite hardy. A clay loam, not too heavy in texture, affords an ideal soil for this crop, provided there is good drainage in the subsoil below. A sandy loam with ample moisture conditions gives also a satisfactory growth. The ground for seed bed conditions should be moist and well firmed, but not hard, and in good surface tilth, so as to render plant food easily available to the young plants. The writer is well aware that some successful pea farmers in Colorado seed this crop in grain stubble, with a disk drill, with profitable results, but a well prepared seed bed would have given more profitable returns. Plow in the fall where possible, spring disk, firm and level the ground for seeding.

SEEDING THE CROP—As early as the season will permit seed the crop. This should be the very first crop the farmer should plan to put in, after the frost is out of the ground sufficiently to get the seed bed ready for seeding. Many Colorado farmers find the grain drill one of the most satisfactory seeders which they can use. They stop up every other hole, or seed two holes and stop up two right through the drill box. This places the rows sixteen inches apart (most drills in the west are eight-inch drills), or two rows eight inches apart, with twenty-four inches between each pair of rows. If cultivation of crop is planned the latter method is the preferable one.

Since the vines have a tendency to a recumbent growth, many farmers seed oats or barley with the peas to hold them up. The proportion is varied to suit their conditions and the purpose for which the crop is grown.

The amount of peas used to seed the ground varies with locality, climatic conditions, purpose for which the crop is grown and the size of the peas used for seed. Some farmers use as high as 100 pounds per acre, while farmers in the San Luis valley, where 75,000 acres are being grown, use from thirty-five to fifty pounds per acre. In this valley the pea vines grow from six to twelve feet long and when seeded too thick, lack of sunlight blights the blossoms; pods therefore fail to form as plentifully as they should and the grain yield is seriously cut down. The small varieties of peas generally produce the greater proportion of forage.

HARVESTING THE CROP—If the crop is to be cut for hay or forage chiefly, it is best to cut when 75 per cent. of the peas are coming into the middle dough stage, or the pods turning from green to yellow in the ripening stage and the vines have still a rich green color.

The method of cutting, at the present time, is not wholly satisfactory. A mowing machine with a good strong high pea guard attached to the sickle bar is generallly used for cutting the peas, but the rank growth of vines tends to clog up the mower, even with the pea guard attachment, and Prof. Bainer, the Farm Mechanics Instructor at the Agricultural College, is seeking a better device to help the pea farmers cut their pea forage with more satisfactory results. When the crop is cut, it is cured and stacked in the same way alfalfa hay is put up. When the grain is the main purpose of the crop, permit 80 per cent. of the peas to get into the hard dough before cutting. Cure and stack as in the first instance.

The peas can be threshed by the grain separators if concaves are removed and care be used in the threshing operation to avoid cracking the peas. A pea huller or thresher is made especially for separating the grain from the forage, which does much more satisfactory work than the average grain thrasher and is recommended where sufficient areas of peas are grown for grain to justify the purchase of such a machine.

SAN LUIS VALLEY METHOD OF HARVESTING—For years the farmers of the San Luis valley grew grain crops successfully, grain following grain, until the yields were reduced too near the cost of production for grain farming to prove profitable. It was then two good "down east" farmers who had grown peas "back home" tested the value of the peas as a valley crop and found they did well in that environment. One of these farmers conceived the idea of turning in the sheep when the peas were ripe to fatten on the crop and save the expense of harvesting. The plan worked out very successfully and gave to the valley a new crop and a most profitable feeding industry. Lambs were procured from New Mexico and Utah and turned on the pea fields when ripe to fatten on this most excellent forage and grain ration. The feeding season was all that could be desired, usually cool, clear and dry, so that all that seemed nceessary was a coyote-proof corral for night and a good shepherd to direct and control the sheep while feeding by day. This harvested the crop, distributed a valuable manure on the pea field, and produced a very superior mutton in from ninety to 120 days. By 1903 it was no uncommon sight to see fields of eighty, 160 and even 320 acres given over to this crop, and at the close of the feeding season lambs came out of these San Luis valley pea fields by the thousands to find a market peculiarly and largely their own.

In the midst of the feeding season 1904-05 came one of the worst snowstorms known to the valley, covering the peas in the field many inches deep with snow, preventing the lambs from foraging until weather conditions melted the snow sufficiently to get at the peas. No peas had been harvested and stacked to tide the lambs over such storms until they could gather their own feed in the field. It was a crisis, which happily lasted but a few days. In the fall of 1905 over 250,000 lambs were estimated to have been brought into the valley to be fattened on the pea crop. Many new settlers, not familiar with pea culture, nor lamb feeding, joined with their neighbors in this heretofore lucrative business. The peas that year made a luxuriant growth, but the blossoms failing to set the usual percantage of pods, the feeding value of the pea fields was seriously cut down, while the lamb crop brought in to be fattened was in excess of former years. This forced many to send to market lambs improperly finished, since the feed was entirely exhausted.

This worked a hardship to all the valley feeders, brought down the price of lambs and caused many to suffer serious loss. In the fall of 1906 many farmers cut and bunched their peas in the field, but the writer strongly urges pea farmers to cut and stack at least a portion of the peas to provide ample forage for lambs in case of severe storms as in the last two winters.

Care in selection of better grain producing peas, methods of seeding and irrigation, which will encourage grain production and lessen vine growth, is strongly urged. We should encourage a study of field

peas, increasing to 3,000 pounds of grain per acre as a desired standard. To this end, the writer distributed 30,000 pounds of a very choice grain yielding strain of field peas this season, hoping in this way to assist farmers of this great pea raising valley to gain that which will increase meat production from this valuable grain and forage crop.

Field peas belong to the same class of plants as clover and alfalfa and have the same effect in enriching the soil, and thereby increasing the yields of all crops that follow them.

Press Bulletin No. 41. April, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

Pruning Locust and Catalpa Trees for Timber

B. O. LONGYEAR.

Trees planted for timber purposes should be encouraged to form tall, straight trunks, free from lateral branches as far as possible. A forked trunk is objectionable, as it cannot be cut to advantage into posts, and furthermore such trunks are subject to injury by splitting down when loaded with snow and ice or in strong wind.

Under the conditions existing, in a good forest the trees not only tend to run up slender and straight, but a natural pruning of the lower limbs takes place, due to shading. In the artificial tree plantation these conditions may be secured by planting the trees close together at first. But if planted close enough to secure this natural pruning the trees soon suffer from lack of room for a good development of the root system, with a consequent stunting of the growth. It is necessary, therefore, to resort to artificial pruning where the trees are set far enough apart to allow for a free root growth and room for cultivation.

In the case of seedling trees that have been properly cut back when planted a number of stems often arise from near the ground, thus forming a bush-like growth. The young trees should be allowed to grow in this form until the following winter or spring, when all but the most vigorous, upright stem shoud be removed, and all suckers kept down.

THE LOCUST.

The black locust is to some extent self-pruning. It is, however, inclined to fork if allowed to take care of itself. This may be pre-

Press Bulletin No. 42. April 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

WESTERN SLOPE FRUIT INVESTIGATION

Condensed Report of Field Entomologist*

SEASON OF 1906

E. P. TAYLOR, GRAND JUNCTION, COLORADO

CODLING MOTH.

The number of sprays required to control the codling moth in an orchard will depend principally upon (1) previous infestation of orchard; (2) proximity to other infested orchards; (3) efficiency of earlier sprays, and (4) variety of fruit.

Time to Spray—The time to apply the first spray is determined by the condition of the calyx of the bloom. This time is folowing the dropping of the petals but before the closing of the calyx. A period not to exceed from five to seven days for any one variety would cover the time when this first spraying should be done. The center blossoms are invariably the first to open their petals and first to drop them. They are first to close their calyces and most likely to set fruit which will remain without dropping from the tree. It is therefore evident that this first spraying should be done with these blossoms in mind. Sixty per cent. or more of the first generation worms, according to this summer's observations, entered at the calyx. For the remaining forty per cent. or less, entering at the side or stem end of the apple, a second spray must be applied early enough to coat the surface of the small apple with poison before the hatching worms make their appearance, and this coating must be maintained upon the fruit until the first generation eggs have hatched.

(This press bulletin is abstracted from Bulletin No. 119, which contained the general report of the Field Entomologist, Western Slope Fruit Investigation for 1906.)

Other conditions being right, one spraying with an adhesive arsenical will perform this end, making two sprays required to destroy the first generation. There being but two full generations of the insect through the season, if the first be destroyed there should be no second left with which to contend. In common practice there will be cases where more than two sprays are necessary, and these additional ones should be directed against the second generation.

It is possible that a general rule may be made for common use, based upon the blooming of the fruit in spring. Such a general rule is herewith presented. Observations upon the time of appearance of the insect in any of its stages could be made to supplement the general rule. The efficiency of the first two sprays suggested will largely determine the necessity of the later ones.

General Rule—(1) Petals off; calyces open; (2) (a) One month from full bloom. (b) Three weeks from center calyces closing. (c) When apples are about three-fourths of an inch in diameter; (3) one month from (2); (4) two weeks from (3); (5) two weeks from (4).

Kind of Spray—The experiments of the year showed Swift's arsenate of lead slightly superior to the arsenite of lime, so far as killing effect upon worms was concerned. It is more convenient and less likely to injure foliage. Asenate of lead when improperly made may cause injury to foliage and fruit from an excess of free arsenic contained. Injury to trees from arsenical sprays is more or less dependent upon variety of fruit and meteorological conditions at time of spraying. A practice among some orchardmen has been to use arsenate of lead for the first and second sprays, and if further spraying is found necessary, the cheaper arsenite of lime is substituted.

Swift's arsenate of lead is commonly used at the rate of twelve pounds of paste per 200 gallons of water. Arsenite of lime is used at the rate of one pound arsenic, four pounds sal soda, thirty pounds lime per 200 gallons of spray, the arsenic and sal soda being boiled together in a small quantity of water for fifteen minutes until dissolved, after which the lime slacked with water to form a milk was added.

Method or Way to Spray—In the experiments of the year it was shown that the method of application had more to do with success than a difference in insecticides used.

For the early spraying a coarser spray of liquid is desirable. At this spraying the tree should be drenched with a strong, driving spray. It should be directed straight into the calyx cups. At spraying time an average apple tree has two-thirds of its blossoms pointing upward and one-third downward. It is, then, apparent that spray must be directed in both these directions. It was found necessary with full-bearing trees, in order to insure thorough work, that spraying be directed downward from the top of a tower constructed over the spray wagon. Spray poles eight to twelve feet long should be used by both ground and tower men.

For the later sprays, a nozzle producing a fine mist is desirable. A nozzle of the double-vermorel type, arranged in such a way that the direction of the nozzle can be placed at any angle with the spray pole, is wanted. The size of the aperture wanted in the nozzle cap will depend upon the pressure maintained. Higher pressures economize upon material and time, and under ordinary conditions are most desirable.

The complete details of the summer's experiments and observations upon the codling moth will be available in a special bulletin issued by the Colorado Agricultural Experiment station, which bulletin is now under preparation.

HOWARD SCALE.

This pest is one of greatest importance to the pear growers of parts of Colorado. Besides the pear, it is known to infest prune, plum, apple, almond and certain shade and forest trees.

Experiments conducted showed the insect to be possible of cheap and complete control by spring applications of the lime and sulphur wash.

Bulletin No. 122 and Press Bulletin No. 30 upon this pest have been recently issued, based principally upon this season's investigations, and may be had upon application.

PEACH TWIG BORER.

The peach twig borer is one of the most important pests to the peach growers of western Colorado.

The injury is caused by a small pinkish brown worm, with black head, measuring, when fully grown, about one-half inch long. The worm is the immature stage of a small grayish moth. The winter is passed by the worm, still very minute, in small chambers hollowed out within the spongy tissue of the bark at the crotches of small limbs. Early in the spring, at about the same time the foliage of the peach shows as small green tufts upon the tips, the worms leave their burrows and attack the tender twigs, boring into them near their tips. This injury to the terminal tips constitues an important injury to the tree. Young peach trees are usually worst infested.

The second generation of worms brings about another injury to the peach crop by making their way directly into the forming fruit, producing the "gummy" peach.

Former recommendations for the control of this insect have been for spring applications of lime and sulphur washes. This has, in fact, been a most successful treatment, but the use of lead arsenate against the twig borer of peach is destined to meet with equal popularity when its efficiency, cost and convenience of preparation and application are considered.

The arsenate of lead is recommended at the rate of three pounds of the paste to fifty gallons of water. The lime and sulphur wash

should be used at the rate of fifteen pounds lump lime and fifteen pounds flowers of sulphur per fifty gallons of water, the two ingredients being boiled together in a small amount of water, for forty-five minutes, then diluted with enough cold water to make fifty gallons of spray. The two sprays, as applied, are of about equal cost—each a trifle over one cent per gallon, exclusive of cost of preparation. The arsenate of lead spray is far more convenient, quicker in preparation and more pleasant to apply.

The spraying should be done at the time when the majority of the blossom buds are first showing their pink tips and as a rule while they are unopened.

Any arsenate of lead spray applied to peach trees must not contain free arsenic, as they are easily damaged by impure lead or lead diluted with water to contain too high a per cent. of the poison, though pure.

OTHER OBSERVATIONS.

The peach tree borer was found doing considerable damage to peach trees in parts of the Grand Valley, having evidently been brought to the county upon nursery stock imported from eastern states. The green aphis and the woolly aphis of the apple were both unusually abundant and destructive. The importance of all of the above mentioned pests to the fruit growers made careful and exhaustive experiments of control imperative and such are now being conducted against them.

Other insect observations made during the season were upon a small grayish brown beetle, doing injury to buds on grafted pear and young apple trees; a pink or salmon colored aphis infesting the buds of peach; aphids infesting plums and elms; the green fruit worm gouging holes into the forming fruit, of apple mites infesting pear; buffalo tree-hopper, tent caterpillar, hawk-moths, grasshoppers, thrips, brown mite, pear and cherry slug, terrapin scale, Putnam scale, as well as numerous parasitic or predaceous insects doing beneficial service in the orchards.

Press Bulletin No. 43. March 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

Western Slope Fruit Investigation

REPORT OF FIELD HORTICULTURIST

The first edition of Bulletin 118, which gives in detail the report of the Field Horticulturist, has been exhausted and, realizing that it contains much that is not of interest to the average fruit grower, the preparation of a press bulletin is ventured in preference to a reprint of the original bulletin. It is hoped that in a few words a summary may be given of the work that is of most interest to the fruit growers.

PLANT DISEASES.

The plant diseases which the fruit growers of Colorado must combat are by no means numerous, but are nevertheless important.

ALTERNARIA—During the past season experiments were undertaken to determine the best method of controlling this rot, which was thought to be injuring the fruit and foliage of Kieffer pears and Ben Davis and Gano apples. The injury was characterized by black blotches upon the surface of the fruit and brown deadened areas in the tissue of the leaves. On the fruit of the apple these deadened areas appeared about the stem or in the blossom end, but in the case of the pear they might appear at any point on the surface.

These experiments, supplemented by careful observation in many orchards, seem to warrant the conclusion that much of this injury is due to burning with improperly prepared or unadapted arsenical sprays. The Keiffer pear is very susceptible to injury from the use of some of these sprays, and should, I believe, be sprayed only with a standard or tested brand of arsenate of lead. Spraying this variety with arsenite of lime is hazardous at any time and especially after

July 1st. If Ben Davis and Gano apples are to be sprayed with arsenite of lime it should be carefully prepared and applied during fair weather only.

PEAR BLIGHT—Pear blight in its various forms has done serious injury, especially in neglected orchards, during the past season. Greater care should be exercised in cutting out diseased wood. The planting of susceptible varieties should be discouraged. Some of the most resistant are Kieffer, Anjou, Mt. Vernon, Garber, Howell, Seckel and Winter Nelis. Bartlett suffers severely when once attacked, but when properly cared for can be profitably grown.

Blossom and twig blight in the apples seems to be on the increase, but with more careful cutting out of the blight in pear trees, it seems that there is no great cause for alarm. The affected trees should be watched closely, and, while it does not seem necessary to remove all blighted spurs, it is quite important that in all cases where it enters larger limbs, it be carefully cut out.

PEACH MILDEW—This fungus has caused some serious injury and has proven itself capable of destroying a crop of peaches in a very short time. Observations made in badly infected orchards show that the disease can be easily controlled. Promptness and thoroughness in carrying out any remedial measures cannot be too strongly urged. Half-strength Bordeaux mixture (2-4-50) should be used during the growing season and a thorough spraying during the dormant season with full-strength Bordeaux should prove a very important safeguard.

GUMMOSIS—Cases of gummosis in peach trees are not uncommon. Gum starts to flow from the trunk or larger branches during the early part of the summer and large drops are formed on the bark, often reaching an inch in diameter and nearly as round as marbles. The bark becomes broken down to such an extent that the tree is girdled and finally dies. Trees in the early stages can apparently be saved by a vertical slitting of the bark about the affetecd part. Make the cuts about two inches apart and as deep as possible with a sharp knife. The recovery of trees thus treated would seem to indicate that the trouble is due to a tightening, or binding, of the old bark.

ROOT ROTS—Two apparently distinct forms of root rots have been found during the season. The form which works entirely below the surface of the ground and on the main roots, seems to have no preference for varieties, while the other which affects the trunk as well as the roots, seems to work exclusively on the Ben Davis and Gano. Both have been found working on apple trees only. The latter is the most destructive of the two and is characterized by a deadening of the bark upon the trunk and main roots and often extending up onto the main branches. Affected trees can most readily be picked out by an early bronzing of the foliage in the fall. At present the only treatment that promises to hold these root rots in check is the prompt removal of diseased trees.

PHYSIOLOGICAL TROUBLES—Many yellow pear trees have come under observation during the season, and in most cases the trouble can be attributed to poor soil conditions, probably to excessive watering.

COPPER SULPHATE INJURY—Copper sulphate has been placed about trees with injurious results. When taken up by the roots in strong solutions it deadens the tissue through which it passes. Its use should be discouraged, as it has not been proven of any value in combating root diseases.

ARSENICAL POISONING—The stock solution used in preparing arsenite of lime, and made by dissolving white arsenic in water and sal soda, is very destructive to plant life. The practice of keeping this solution under a tree in the orchard should be abandoned. A very small amount spilled on the ground may mean the loss of the tree. The fumes given off by this material when being boiled is injurious to plant life and the boiling should be done at some distance from the orchard.

GRAPE GROWING—The grape growing industry is still in the experimental stage. Difficulty is experienced in getting the crop to market in good condition. Our season is rather short for some varieties and lack of ripeness, or better stated, a low sugar content, is one quality much against our grapes, as it is generally conceded that a grape must be ripe to carry well. Greater care should be exercised in cutting out injured berries and longer time given for wilting before packing. Grapes packed while the stems are stiff split badly and offer a good entrance for molds.

Water should be used more sparingly in the vineyard and dry soil conditions should prevail through the ripening period. The general tendency seems to be to prune too short and a light crop of inferior bunches is the result. No varieties should be pruned shorter than four buds and the Muscat, Sweetwater, Sultana, Emperor and Thompson Seedless give better results when pruned to eight joints.

As to varities, the Tokay and Cornichon seem best adapted to the Palisade region. For other districts where the season is shorter, the Muscat, Rose of Peru, Zinfandel and Black Ferrara will be better adapted.

GENERAL ORCHARD CULTURE

Some of the orchard soils are rather heavy to be handled well under irrigation and, with the method of watering commonly used, it is impossible to cultivate some of these orchards from the time the first water is applied in early summer until the following spring. It is often the case that shallow furrows are used with a large head of water, the result being a flooding of the whole surface. When dry enough to work again the soil has baked so hard on the surface that it is impossible to cultivate it. The grower then resorts to frequent

watering to keep the orchard going. In these heavy soils the water settles slowly and a smaller head run in deeper ditches would no doubt prove more satifsactory.

I think growers with these heavy adobe soils should also resort to the planting of cover crops to improve soil texture. They could gradually be brought into condition where they could be more easily handled after irrigation. Growers, as a rule, pay too little attention to the sub-soil. Too often, the rule followed is, if you can kick up dust on the surface, irrigate. The appearance of the tree indicates to a great extent its needs, but after all, it is an examination of the sub-soil which most surely determines whether the orchard needs water or not.

General rules which it might be well for growers to follow in applying water are as follows:

The more sandy the soil, the greater number of ditches, the shorter the run in both time and distance.

The longer the ditches, the larger the head.

The stiffer the soil, the fewer and deeper the ditches, the longer the run in time and distance, and the smaller the head.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO

Spraying for Codling Moth

SOME IMPORTANT POINTS TO BE CONSIDERED.

By C. P. GILLETTE.

Get ready for the work as soon as the first apple blossoms begin to open.

Do not fail to begin the first spray as soon as the blossoms are nearly (say 90 per cent.) off.

Have outfits enough to complete the first spraying within eight days from the time it is begun; or if you have varieties that bloom at different times, arrange the work so that none of the trees will have to wait more than one week from the time the petals are off until they are sprayed.

A good power outfit for spraying will do to take care of 20 acres of apple orchard that is twelve or more years of age. It will be a mistake to expect it to do much more than this.

Large trees require from six to ten gallons of liquid each for a thorough first spray. If the average is eight gallons and there are eighty trees to the acre, it will require sixty-four tanks of two hundred gallons each to make the application.

If the weather is warm, some varieties will close their calyces within six days from the time the petals are off, and the little apples that close their calyces first, are the ones most likely to set and make fruit.

When making the first spray you must determine upon one thing if you are to get anything like perfect fruit, and that is to *stay with each tree until every calyx has been filled with the spray.* Stop occasionally to examine the blossoms to find out whether or not you are doing this. This is of more importance than all the rest of the advice of this bulletin put together.

Thorough first spraying can not be done, except with a great waste of material, with a short pole by men standing upon the ground. Do not spray all sides of a large tree at one stop; spray only the halves of the trees next to the wagon upon either side.

With large trees, always have a tower or platform above the tank where two men may stand with long rods to spray downward while one or two men with short poles upon the ground spray upward through the trees.

A pressure of 100 to 150 pounds is sufficient to do good work if proper nozzles are used.

Use a good quality of poison and little or no lime. I prefer to use no lime with arsenate of lead. With Paris-green use the same weight of lump lime that you use of the poison. Good results may be obtained by the use of any of the common arsenical preparations. I prefer them in the following order: One of the standard brands of arsenate of lead, Kedzie arsenite of lime, Paris-green. Use five or six pounds of arsenate of lead, one-half pound of white arsenic (in the arsenate of lime), or one pound of Paris-green to each 100 gallons of water. Make the first treatment so thorough that it will not be necessary to repeat the spray within ten days.

Make a second treatment one month after the first.

Make a third application at the end of another thirty days unless the apples were quite free from worms the previous year, and in any case if any considerable number of wormy apples can be found in the orchard. Three sprayings should be sufficient. Spray again in three weeks if it seems necessary.

Two good sprayings applied thoroughly and at the proper time should save, at least, 90 per cent. of the fruit, and three should save from 95 to 99 per cent. Many orchardists in Colorado are doing better than this.

Pass all water entering the spray tank through a fine-meshed sieve or strainer to remove all particles that might clog a nozzle.

Never plant apple trees nearer than 24 feet either way in the rows or they will crowd so as to prevent good spraying as they become large. If you fail to make the first application thorough and at the proper time, you will fail to get a clean crop of fruit.

When you have learned to spray most effectually, it will no longer be worth your while to use bands to catch the worms.

Protect the doors and windows of fruit houses and cellars with screen doors that will not allow the escape of the moths that hatch out in these places.

Clean culture, and especially the stirring of the soil about the trunks of the trees, will prevent the worms from successfully undergoing their transformations under clods and about the crown of the trees.

Do not be discouraged because your neighbor does not properly attend to his orchard. You can get fairly good results anyway, and in this manner you will educate him to be a better orchardist and citizen.

The success of apple growing in this State must depend upon the reputation of Colorado apples. Their reputation at the present time is an enviable and just one, but it will quickly vanish into thin air just as soon as Colorado orchardists fail to keep up the high quality and honest pack of their fruits. So, for your own credit as well as for the success of Colorado fruit growing, do not forget, among other things, to do your best to grow big, perfect apples, free from worm holes and other imperfections.

The Experiment Station wishes to aid you. Feel free to ask questions, which will be answered, so far as possible.

Press Bulletin No. 45. April 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

THE SPRING GRAIN-LOUSE*

BY C. P. GILLETTE.

A small green plant louse, which is being called the "green bug" in some of the papers of the country, is doing serious damage to winter wheat in parts of Colorado, especially in the lower Arkansas valley. It would be well for all who are growing wheat in Colorado to be on the watch for brown spots in the wheat fields, due to the dying grain. Where these spots appear it will probably be found upon investigation that the cause is a small green louse, clustered upon the stems and leaves of the plants. A good way to detect the lice is to brush the plants and then examine the ground beneath them.

If the lice are at all abundant, reddish or yellowish lady-beetles with black spots and a sort of worm or grub about one-third of an inch long, dark in color with yellow markings, will be noticed in company with the lice. These grubs are the young of the lady-beetles, and both are the friends of the farmer, as they feed upon the lice. Where the lice are found in any considerable numbers, if they do not destroy the wheat crop, it will be because these lady-beetles and some other natural enemies of the plant lice increase in numbers enough to eat the lice before they kill the wheat.

CAUSE OF THE LOUSE.

This has been a well-known pest upon wheat and other grains for several years in the States that grow winter wheat, and I have known of its presence in small numbers in Colorado for several years. The great increase this spring is probably due, first, to the small

*Toxoptera graminum Rond., see Circular 35, U. S. Bureau of Entomology by Webster.

number of its natural enemies last fall, and, second, to the mild winter and early spring, which have favored its early increase in numbers. There can be little doubt but what the lice have been able to hibernate in all stages in the wheat through the winter.

In the sections I have visited, the lice were doing more injury to early than to late sown grain, and were more numerous in fields that were in to grain last year than in those that were planted to some other crop.

HOW LONG WILL THEY LAST?

I have been asked this question many times. The grain louse is probably with us to stay. It is probable that its natural enemies will keep it in check most of the time, so that it will only attract the attention of grain growers in occasional years, when the small number of its enemies and the weather conditions favor its increase.

The lice may remain in the wheat until the latter ripens, unless killed out earlier by its insect foes.

REMEDIES.

What can be done where the lice are in the wheat?

The application of coal oil emulsion or soap solutions in the form of a spray as for other plant lice would kill them, but I seriously doubt such applications being practical, unless it be in choice plots of seed grain.

Where the lice are very abundant and the grain seems to be dying rapidly and turning brown in spots over the field, I believe the safest plan would be to plow it under and put some other crop upon the land before it is too late, as the grain can only make a light crop at best. Anything but grain crops, such as wheat, oats, barley and rye, could be put upon the land. Potatoes, melons, corn, beets, peas, or reseeding to alfalfa would be all right. It is possible that this louse might injure corn to some extent.

If the lady-beetles are very numerous and the lice seem to be decreasing in numbers, it would be well to wait a few days and then decide whether or not the enemies of the plant lice are likely to destroy them in time to save the crop. If the prospect is very bad for the saving of the crop, the sooner it is turned under the better.

Press Bulletin No. 46, May, 1907

The Agricultural Experiment Station

FORT COLLINS, COLORADO

ADVICE TO PLAINS SETTLERS

BY J. E. PAYNE.*

We recognize it as a fact that many new settlers have taken up residence in the Plains region during the last few months who have merely enough capital to put up houses, break a few acres of sod, and live during the first six months.

The people cannot wait for results promised by the exploiters of "Scientific Soil Culture." They must have results this season. It is to this class of people that we would address the following suggestions:

First. If you have a milch cow, give her the best care possible, and get as many more as you can. Sell cream, or make good butter or cheese. Sod cowhouses are within the reach of all who can work.

Second. Keep as many hens as you can take care of. Feed well and protect from coyotes and other beasts of prey. If you can raise turkeys and geese, they will pay. Turkeys and geese may be herded by children, and turkeys are the best grasshopper exterminators known.

Third. For field crops on sod, plant early amber cane, yellow Milo maize and corn. The seed corn used should be grown in the vicinity if possible, if not, choose some early variety. If you are able to do so, prepare a small field for fall wheat.

Fourth. Plant a garden. If you have no well, plant a small plat near the house and water it with the waste water. Bury every drop of waste water beside some vegetable by making a furrow beside the plants and after the water has sunk away fill the furrow with dry dirt. Old tin cans sunk in the ground by the side of hills of cucumbers aid in watering them economically. Punch holes in the bottoms of the cans.

If you have a well, plant a large garden, but plant all garden stuff

*The writer has fought grasshoppers and drought in Eastern Colorado for many years. Besides early training in Kansas, he was in charge of work on the Plains for the Colorado Experiment Station from 1896 to 1904, as Superintendent of the Sub-station at Cheyenne Wells, and as Field Agent for the Experiment Station. Is now in the employ of the U. S. Department of Agriculture in the Dry Land Division, located at Garden City, Kansas.

in rows so that it may be cultivated with horse power. Use the water with the same economy that you would if using only waste water. Never flood the ground purposely. If any should be flooded, stir it thoroughly as soon as it is dry enough.

It is a common mistake with beginners in irrigation to try to make water take the place of cultivation. The result is failure. Another common mistake is to plant a larger area than can be watered from the well. Better begin with only a few square rods and extend the area as experience dictates.

In case you cannot irrigate from a well, select a small patch of ground upon which you can turn the flood-water from the prairie by means of furrows. If you can make a small reservoir above the patch, do it. The reservoir may hold a few barrels of water until you have time to direct it to the plants which need it. Cultivate thoroughly and keep all weeds down.

Besides the small truck, a good patch should be planted to Mexican beans, early cow peas, watermelons, muskmelons, stock melons, pumpkins, squashes, popcorn, sweetcorn and potatoes. These will sometimes bring good crops without irrigation. Enough should be planted so that a plentiful supply of winter food for the family will be assured. Stock melons are very productive, and if stored in sod buildings, above ground, they will furnish green food for the milch cows during winter. I have grown stock melons at the rate of 20 tons per acre. I have kept ordinary watermelons until the last of November by packing them in hay and storing in a room where they kept cool, but did not freeze. There are varieties of winter watermelons and muskmelons which are good from Christmas until March.

By planting the following seven varieties of sweetcorn on the same day—and often near the last of May—I have had roasting ears from July 26th, until September 26th. The varieties were: Cory, Black Mexican, Perry's Hybrid, Stowell's Evergreen, Country Gentleman, Mammoth Evergreen, and Egyptian. The large varieties may be dried for winter use or allowed to ripen to be used parched. Parched sweetcorn is a luxury, but one which is within the reach of the poorest settler. White Pearl and Queen's Golden popcorn have done well for me, and my family have had many meals consisting only of whipped cream and popcorn.

Potatoes, squashes and pumpkins may be grown successfully by keeping up a constantly successful fight against potato beetles and squash bugs. This means to battle almost daily with the pests from the time the potatoes are up until the middle of August, and from the time the squash plants are up until the squashes are ripe. To describe methods of fighting these pests would require volumes, but we advise you to use your ingenuity in killing them. I preferred to kill them with clubs.

Grasshoppers are the worst enemies to field crops, but by keeping plenty of poultry, the grasshoppers will be kept down.

To produce crops of any kind may require an amount of labor which seems enormously out of proportion to the market value of the

produce; but we assume that people who have settled here desire to build up homes and they have come here because they failed to get homes elsewhere. It may be a comforting thing to remember that you may not be working any harder here while trying to establish independence than you would be if working by the day for some one for just enough wages to support yourselves.

The following bulletins and reports deal with the Plains:

BULLETINS.

59. Field Notes on Trips in Eastern Colorado .....J. E. Payne
77. Unirrigated Lands in Eastern Colorado .....J. E. Payne
87. Cattle Raising on the Plains .....J. E. Payne
88. Dairying on the Plains .....J. E. Payne
89. Wheat Raising on the Plains .....J. E. Payne
90. Unirrigated Alfalfa on Upland .....J. E. Payne
103.* The Thorough Tillage System for the Plains of Colorado..W. H. Olin

PRESS BULLETINS.

16. The Prairie Dog as a Range Pest .....J. E. Payne
17. Trials of Macaroni Wheat by Dry Farming .....J. E. Payne
18. Crops for Unirrigated Lands .....J. E. Payne
33. Dairy Work for Plains Settlers .....H. M. Cottrell
34. Acclimated Seeds—(Hints for New Settlers in Eastern Colorado) ..... W. H. Olin
35. Wind-Breaks and Shelter Belts for the Plains ..... B. O. Longyear
36. Preparation of Seed Bed ..... W. H. Olin
37. Potatoes on the Plains ..... E. R. Bennett
38. Grasshoppers Upon the Plains ..... C. P. Gillette
39. Summer Culture to Conserve Moisture—(Hints for Plains Settlers) .....W. H. Olin

REPORTS.

7th Annual Report—1894— 4-page report by .....J. B. Robertson
8th Annual Report—1895— 6-page report by .....J. B. Robertson
9th Annual Report—1896—11-page report by .....J. E. Payne
10th Annual Report—1897—16-page report by .....J. E. Payne
11th Annual Report—1898—15-page report by .....J. E. Payne
"Report of Six Years Trials at the Plains Substation." (Excerpt from the 12th—1899—Annual Report of the Experiment Station).J. E. Payne
13th Annual Report—1900—13-page report by .....J. E. Payne
"Notes on the Plains." (Reprint from the 14th—1901—Annual Report of the Experiment Station) .....J. E. Payne
15th Annual Report—1902— 5-page report by .....J. E. Payne
15th Annual Report—1902— 2-page report by .....J. B. Robertson
16th Annual Report—1903— 6-page report by .....J. E. Payne
16th Annual Report—1903— 2-page report by .....J. B. Robertson
17th Annual Report—1904— 2-page report by .....J. B. Robertson

*All Bulletins except 103, Press Bulletins, and Reports 1898, 1902, 1903, 1906, are still available and may be had on application of L. G. Carpenter, Director, Fort Collins, Colorado.

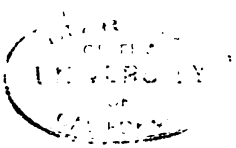
THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE TWENTIETH ANNUAL REPORT

OF

The Agricultural Experiment Station

For 1907



State Board of Agriculture.

	Term Expires
HON. P. F. SHARP, *President*,[1] Denver	1907
HON. HARLAN THOMAS,[1] Denver	1907
HON. JAMES L. CHATFIELD, Gypsum	1909
HON. B. U. DYE, Rocky Ford	1909
HON. B. F. ROCKAFELLOW, *President*, Canon City	1911
HON. EUGENE H. GRUBB, Carbondale	1911
HON. A. A. EDWARDS, Fort Collins	1913
HON. R. W. CORWIN, Pueblo	1913
HON. F. E. BROOKS,[2] Colorado Springs	1915
HON. J. L. BRUSH,[2] Greeley	1915

GOVERNOR JESSE F. McDONALD[3]
GOVERNOR HENRY A. BUCHTEL
PRESIDENT BARTON O. AYLESWORTH } *ex-officio.*

EXECUTIVE COMMITTEE IN CHARGE.[4]

P. F. SHARP, *Chairman*

B. F. ROCKAFELLOW. A. A. EDWARDS.

EXECUTIVE COMMITTEE IN CHARGE.[5]

B. F. ROCKAFELLOW, *Chairman.*

A. A. EDWARDS. B. U. DYE.

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[1] Term Expired April 10, 1907.
[2] Term Began April 10, 1907.
[3] Term Expired January 1, 1907
[4] To April 10, 1907.
[5] Since April 10, 1907.

STATION STAFF.

L. G. CARPENTER, M. S., *Director* ---------- Irrigation Engineer
C. P. GILLETTE, M. S., ---------- Entomologist
W. P. HEADDEN, A. M., Ph. D., ---------- Chemist
WENDELL PADDOCK, M. S., ---------- Horticulturist
W. L. CARLYLE, M. S., ---------- Agriculturist
G. H. GLOVER, M. S., D. V. M., ---------- Veterinarian
W. H. OLIN, M. S., ---------- Agronomist
R. E. TRIMBLE, B. S., ---------- Assistant Irrigation Engineer
F. C. ALFORD, M. S., ---------- Assistant Chemist
EARL DOUGLASS, M. S., ---------- Assistant Chemist
S. ARTHUR JOHNSON, M. S., ---------- Assistant Entomologist
B. O. LONGYEAR, B. S., ---------- Assistant Horticulturist
E. B. HOUSE, M. S., ---------- Assistant Irrigation Engineer
F. KNORR, B. S., ---------- Assistant Agronomist
P. K. BLINN, B. S., ---------- Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S., ---------- Potato Investigations

STATE FRUIT INVESTIGATIONS, GRAND JUNCTION.

O. B. WHIPPLE, B. S., ---------- Field Horticulturist
E. P. TAYLOR, B. S.,[1] ---------- Field Entomologist

OFFICERS.

President BARTON O. AYLESWORTH, A. M., LL. D.

L. G. CARPENTER, M. S., ---------- Director
A. M. HAWLEY, ---------- Secretary
MARGARET MURRAY, ---------- Clerk

[1] Resigned October 15, 1907, to become Entomologist, State Fruit Experiment Station, Mountain Grove, Missouri.

LETTER OF TRANSMITTAL.

To His Excellency, Henry A. Buchtel, Governor of Colorado:

In accordance with the conditions of the act of Congress which requires a full and detailed report of the operations of the Experiment Station, I have the honor to present herewith the Twentieth Annual Report.

The financial statement is for the fiscal year ending June 30; the other portions being reported substantially for the current year.

L. G. CARPENTER,
Director.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1907.

RECEIPTS.

DR.

	Hatch Fund	Adams Fund	State Fund	Special Fund	Totals
From the Treasurer of the United States as per appropriations for the fiscal year ended June 30, 1907, under acts of Congress approved March 2, 1887, (Hatch Fund) and March 16, 1906, (Adams Fund)...	$15,000.00	$7,000.00	.....	.....	.....
Balance on hand July 1, 1906	.....	.....	$2,364.52	.....	.....
Miscellaneous	.....	.....	.....	$7,497.68	.....
Total Receipts					$31,862.20

DISBURSEMENTS.

By Salaries	$ 9,111.27	$4,614.81	$ 843.33	$1,069.96	$15,639.37
Labor	1,200.34	701.55	276.02	695.95	2,873.86
Publications	1,914.26	.....	.....	2,266.47	4,180.73
Postage and Stationery	616.07	93.07	17.60	159.16	885.90
Freight and Express	522.23	108.57	12.50	198.38	841.68
Heat, Light, Water and Power	5.90	.....	.....	16.30	22.20
Chemical Supplies	.....	38.05	.....	12.45	50.50
Seeds, Plants and Sundry Supplies	203.12	23.15	53.54	80.54	360.35
Fertilizers	.....	.....	.....	.....	.....
Feeding Stuffs	11.10	.....	.....	431.86	442.96
Library	1.80	655.26	.....	3.00	660.06
Tools, Implements and Machinery	19.50	.....	17.00	11.00	47.50
Furniture and Fixtures	90.29	28.45	42.25	22.95	183.94
Scientific Apparatus	131.59	228.34	5.20	98.64	463.77
Live Stock	.....	.....	.....	533.30	533.30
Traveling Expenses	704.93	508.75	175.90	500.17	1,889.75
Contingent Expenses	21.00	.....	841.24	227.85	1,090.09
Buildings and Land	446.60	.....	79.94	327.37	853.91
Total Expenditure	$15,000.00	$7,000.00	$2,364.52	$6,655.35	$31,020.20
Balance				842.33	842.33
				$7,497.68	$31,862.20

REPORT OF THE DIRECTOR

To The State Board of Agriculture:

Gentlemen—In this report as Director I will discuss more the general problems of the Station, and those which pertain to the work and policy as a whole, and will attempt to give information which bears upon the general work, and to show what the Station is doing.

The variety of work has had a tendency to increase. Funds from State and other sources have served to extend the work so that more topics need to be discussed than usual. The Station, and in fact all of the Stations of the United States, are at a turning point in their history, are hunting for light, and feeling their way toward their proper function. It was a number of years after the Hatch Act was passed before the Stations as a whole grew to their responsibilities and came to a clear understanding of their proper scope.

With the passage of the Adams bill another period in their life comes, which involves not only the interpretation of the law but also a growth of the idea of important scientific research. It will undoubtedly be a number of years before the Stations will have reached a uniformity of sentiment, and have gotten clear light on many of the problems which this Act brings up. The limitations of the Act are at present troublesome, and cause much preplexity to the Stations, and the feeling among many that the interpretation is arbitrary and unnecessary. The provisions of the Act, however, place the control of the funds much more directly in the hands of the general Government than the Hatch fund. This was probably done because some of the Stations at least, did not live up to their duties as institutions for the advancement of scientific investigation along agricultural lines. Some were affected by itching for popular applause, and some had used money in ways that were at least doubtful. While these restrictions are at present the cause of much perplexity, I have no doubt that in the course of a few years it will be generally realized that they have been wise, and that the Stations could not have become so important without them.

The requirements of the bill are such as I have previously pointed out. The additional appropriation is not really an addition to our resources. The requirements are correspondingly great, and in fact such as to make additional demands on our other funds in order to utilize this fund within the requirements of the law. As a consequence it appears that some difference in the relations between the Colleges and Stations will result in the course of a few years. Under the Hatch Act, as commonly interpreted, scientific investigation was secondary, and the fund was often used to supplement the salary of an instructor, when the requirements of investigation gave way to the requirements of the routine work of teaching. The conditions of the

Adams fund, however, are more strenuous, and it would appear that it will be almost inevitable that with those principally engaged in scientific research, the scientific work will be primary and teaching and other work will become secondary. In the past if there was conflict the investigational work had to give way. Under the conditions of the Adams Act, if the two conflict it would look as though the adjustment would need to be on the other side. In other words the requirements are such that the Government is in a position to insist upon conditions favorable to scientific work. While at present most Stations are not so situated, nor as yet enough money from the Adams fund, to justify such conditions, yet it seems to me that the tendency will inevitably be that way. The Government already urges that there be only a few men supported from this fund, and that those men give the large part of their time to this work. This means a force of professional scientists, and the use of the fund to a few men of high type who give the greater part of their energies to such investigation. It must lessen the amount of teaching which they can do, but the final result will be to put such Institutions more of the type of the German Universities. The transition and development is bound to be slow, and possibly painful, but if I forecast the development rightly, the inevitable and final results will show that it is best for the Institutions and for agricultural science. At the start and for a few years there will be misunderstanding and criticism undoubtedly from failure to understand the wisdom of the law, but the situation of the Government is such that it seems to me the result must come.

So much has been done in the name of Experiment Stations that there is not a clear idea among the public as to the scope of the Stations, or their limitations, and this same vagueness of idea is not free from the staff of the Experiment Station. Popular applause is very often, if not generally, given to the work which is not really scientific, and in fact scientists very generally doubt work so heralded. It was the result of wide experience that physicians reached the conclusion that reputable physicians must not advertise.

The Experiment Stations had at the passage of the Hatch Act relatively few trained men to draw from. With the requirements of the Adams Act there are now not sufficient qualified men to meet the demands of the Stations. They should, to some extent, be trained. The requirements are such as to need the most thorough scientific training as a basis, and it should encourage years of preparaiton. Whether we deceive ourselves or not the final standing of the Stations will be fixed by the opinion of scientific men.

A part of the confusion in the consideration of the scope of the Experiment Stations is because of the fact that there are different sources of support, and a Station may have three very different lines of action. It needs to be considered;

(a) As supported from U. S. Government funds
(b) As supported from State Appropriations
(c) As supported by private and other funds

As maintained by the U. S. Funds, that is the Hatch fund and the Adams fund, its powers and its duties are such as are contained in these two acts of Congress. Some things it is prohibited from doing, some things it can do, and some things it is required to do. Under these limitations extension work is not permitted, except as it may be considered as a form of publication, which is permitted under the Hatch Act. This manifestly would be improper, more than to a very moderate degree, for the Act strictly speaking, refers to publication of results. It is to be anticipated that much that has been permitted hitherto under the Hatch Act will be more strictly inspected by the Government in the future.

The Adams fund cannot be used for printing nor for the organization of the Station. None of this fund can be used for the purchase or rental of lands, nor for the operations of farming, nor can they be used directly or indirectly for the salaries of persons whose work is not in connection with the Experiment Station, nor can this fund be used for permanent substations.

Likewise under the State appropriations the Station would be permitted to do whatever may be permitted by the State Act. Thus the appropriation by the Legislature last winter is such that almost anything can be done under the different sections of the Act that may be thought desirable. It is not subject to the limitations of the National Act. Any investigation tending to develop the animal interests of the State, or of the grain and forage interests, or the fruit interests, would be possible. Substations, extension work, the distribution of seeds, and many other things which were not the purpose of the National Act, would be possible under these provisions.

Likewise under the third class such funds as are given by private subscriptions or from other sources, would be subject to their own limitations. Under this may be such as the Delta County subscription of the past year, the Mesa County subscription of the previous year, funds from cooperation with the Government, in each the funds are available for the special purposes provided for. So likewise may be classed the direct support from the State Board of Agriculture. Its powers are so wide that it would legally be possible for them to give funds for almost any purpose.

Inasmuch as the U .S. Department of Agriculture may, and does, do many things which we cannot do under the Hatch and Adams funds, it is sometimes supposed to be inconsistent. This is not so, for its funds are given by Act of Congress, and as these are given annually, and as the conditions are changed from year to year, it is only limited by these conditions, and in that case the funds given to it bear the same relation as the State appropriation does to us. Hence while we may not support a substation from the U. S. funds, the Department of Agriculture may do so, if the conditions of the grant to them are such as to permit it.

Demonstration work, variety testing, the distribution of seeds, etc., and various cooperative work which are perfectly proper under section B are not proper under section A. So publications which may be

proper under either B or C may likewise not be permissible under the Government funds of the Station. Such bulletins are often printed and such work done. Inasmuch as the distinction concerning the source of the revenue, and the conditions is not made confusion often arises as to the work of the Station. The Cornell Experiment Station has had a large appropriation from the State, and thus does much work from these funds that it could not do from Government funds. The Geneva Station also has a large amount from the State, amounting now to nearly $100,000 per annum; and only under conditions made by the Legislature. Hence such stations are not guides as to the limitations of other stations which are largely restricted by Congressional requirements.

It may be desirable to distinguish in the publications, the work done under these different funds, as a means of educating the public and of preventing this misconception which frequently leads to embarrassment and to dissatisfaction which would not arise if the limitations were understood.

It then follows that the conditions and requirements for the workers in the second class of work may be very different. Demonstration work and the work which brings the Station in contact with the public and attempts to put at their disposal the work of the Station and of the College, is exceedingly desirable, but it is not in itself scientific work, nor is it permitted to more than a moderate degree under the terms of the Government grants. These things need to be supported from the State and other funds. The fact that it is not permitted by the Government acts does not show that these officials do not realize its importance and value, but rather that they believe that local support can be obtained for such work much more readily than for the scientific work which should be its foundation, and without which such work would lose its inspiration and its value.

As mentioned before the provisions of the Adams fund do not make the conditions of the Station easier. It was expected that the State appropriations would ease the Station funds, but unfortunately it has not done so, especially during the past year. The general expenses of the Station tend to increase, and must do so inevitably. As more work is done there should be more bulletins published. There is a great increase in the number on the mailing list, and this means a direct increase in the expense of publication.

The Farmers' Institutes and the extension work of Professor Cottrell, have brought a very large addition to our mailing list, so that the cost, with the increase in the cost of printing and of paper, and the great increase in the size of the edition, more than doubles the cost of a bulletin. The envelopes for sending out one edition to the full mailing list, will in the future cost about $50. The work of mailing and addressing these envelopes is very great, and if done by hand would mean several weeks' work. Our present system of addressing the envelopes, which served its purpose with a small list, is now outgrown, and it means an additional expense for another addressing

machine. Hence all of these conditions due to the growth of the Experiment Station mean cost. At the same time our funds available for these purposes are fixed. Further demands likewise occur, and many greater expenses. All of the miscellaneous demands which are in consequence of the Adams fund, come back and are a charge on the Hatch fund, or other funds. All of this means more clerical work, it means more correspondence, and therefore more help throughout the Station as a whole. These miscellaneous expenses must be borne by the Hatch fund, and yet may be a direct consequence of the Adams fund. Hence, as I have stated before, the consequences of the Adams fund are not a relief to the financial situation of the Station, but rather make it more strenuous. To some extent this is also true with regard to other appropriations given to the Experiment Station for other work.

When other funds are given, as for the fruit investigations and from other State appropriations, they have a tendency to cause additional correspondence and therefore additional bulletins. Therefore, it has seemed to me that the only satisfactory way to treat the other funds is to estimate the incidental expenses, like bulletins, postage and stationery, and make them a charge against those funds. This I have endeavored to do, and hence in estimating the expenses of such an investigation as the Delta County fruit investigation, the Mesa County, or the animal investigations, etc., I have included the printing as an essential part of the expense. Otherwise the Hatch fund would become practically nothing but a printing fund, and the Station proper might thus have nothing to do with the line of experimentation.

The last Legislature passed a bill appropriating $45,000, of which $35,000 is essentially for the Experiment Station, as follows:

$6,000 for Animal Industry.
$4,000 for Plant Industry.
$2,000 for Grain House.
$2,000 for Farm Machinery and Building.
$500 for Animal Diseases.
$8,000 for Fruit Investigations.
$7,500 for Purchase of Lands.
$5,000 for Co-operative Horse Breeding Work (Provided the Government will spend $10,000).

One-half of this amount should be available the fiscal year ending December 1st, and the other half during the next fiscal year. It was expected that this money, or a proportionate part of it, would be available immediately after the Legislature adjourned, and it has been expected to be available almost every month since. As a matter of fact it was not available until late in October, this was after the growing season, and therefore it meant that such work had to be continued at the expense of other funds, or else dropped. It therefore has led to an awkward situation We realized the fact that a suspension of the work would mean the destruction of its value, and it has therefore lead to a tendency to use other funds and continue the work. The effect has therefore been to make the Station chronically hard up during the season, and to

rather strain the interpretation to justify the use of other funds. The Government auditing officers have questioned the desirability of doing this.

During the entire season, therefore, the Station has been constantly in the situation where its funds were very low, and has been forced to hold back bulletins, and refrain from other expenditures which were desirable to make This awkward situation has arisen with almost every State appropriation. The appropriation of four years ago has not been received until now. The appropriation of two years ago was not available until late in the fall, and the present appropriation was available November 1st, and there is still doubt as to whether we shall receive the full amount for the coming year. This makes an exceedingly difficult situation to arrange for. If the appropriation be for a building, then the delay in the payment simply means the delay in starting, and no more serious result is apt to arise. In the case of investigation or all work which has to be continuous, then such a delay means either suspension of the work or the depletion of the other funds. It is manifest that such work cannot be suspended for 10 months, or even one month without practical destruction of all value.

This kind of appropriation is exceedingly difficult to manage in connection with the Experiment Station. It is far better to have a less amount, but one which can be depended upon with certainty, and to be paid promptly. Hence it would be far better could we have a mill tax for such purposes, for if the total amount is less than the other appropriation, even then the work like the fruit investigation and plant investigation could be continuous, and avoid the embarrassment and difficulty which affect us throughout the year.

This same shortage likewise affected the appropriation for Grand Junction.

While there has been much objection to a mill tax on the part of the people of the State, yet this kind of appropriation becomes almost impossible to use successfully, unless it be that the Board is in shape to stand the additional draft for the period of delay, and to run the risk of failure to get any money, and thus lose what has been advanced.

THE LOCO INVESTIGATION.

A co-operative investigation of the loco plant and disease has been carried on with the Department of Agriculture. The first work on this was done byMr. Payne, who was given special instruction to collect information concerning the disease and its distribution through the study, and interviewing stockmen. He outlined a course of work but manifestly it required much more funds to take up than we had available. It also seemed as a consequence of the whole inquiry that the most important point to be attacked was to determine absolutely whether the disease was a consequence of the plant or not. The disease occurs in widly separated localities in different states, and the plant recognized as the cause in one locality does not grow in others where the disease is recognized.

An agreement was entered into whereby the department sent an expert and we furnished animals and arranged for land. Dr. Glover was to represent the station and to be consulted concerning autopsies and various other work. The total cost to us has been about $1200, aside from the time and some traveling expenses. Dr. Marsh has represented the Government. The previous investigations had failed to find any poisonous element in the plant. As a basis for final remedy of the disease, the cause must be absolutely known, and while the popular belief of cattlemen was that the plant was the cause, yet that might be as wrong as the supposition that has existed for thousands of years that the miasma of swamps was the cause of malaria, or contagion was the cause of yellow fever. Hence we urged in the investigation the determination of the cause.

Dr. Marsh took up the question in a different way. Instead of attempting to determine the poisonous principles, he used the plant or extracts and studied their physiological effects upon small animals. He thinks he has determined the cause. We are not conversant with the details of the work as performed by them, for this, as in most cases of so-called co-operation, consists of our putting up the funds for work by the Government men.

A summary of some of the conclusions was given in the report of 1905. We hope that a report may be made upon this soon.

THE PLAINS SITUATION.

At a meeting of the Board in April, a petition was presented, asking for a substation at Akron, and giving a subscription of $3,000. The Government representative, Mr Chilcott, was present at the Board meeting in June The subscription given by the people at Akron seems to have been based upon the statement that committed us, in popular impression, to the establishment of a Station, but such statement was without authorization and tended to cause some friction and embarrasment. I think, however, that the matter now is practically straightened out. The Government has taken over the land which the people of Akron had provided and with the funds subscribed, have started a station at that point, which they can do under Congressional appropriation, though we cannot under the Government funds at our disposal. Were we to continue such work on the Plains, the plant which we already have at Cheyenne Wells could be used to best advantage. Its location, however, did not prove to be so desirable for the Government inasmuch as they already had a station in Kansas not very far from Cheyenne Wells, and therefore they desired to go farther away. There may be some echoes still as a result of this action, but I think that little more is to be expected.

The last Congress passed a bill, giving to the College, for forestry experimental purposes, a tract of 160 acres near Akron. The land which the Government has is adjacent to this tract. Up to the present time, we have not received a deed for the land. The last correspondence had with the Commissioner of the Land Office stated that he

would look up and see whether there were any adverse claims to this land, but since I have not heard from him, it was supposed that it would come in the ordinary course of proceedure of that office. Any title which we obtain, however, is conditional on the use for five years for such purpose. No funds have been available. The opportunity seemed to be good and rather than lose a year of time, it was thought best to spend the amount that would be necessary for plowing a part of the ground. Accordingly a total expense of about $50. was spent in the plowing. The Government asked us to build a fence on the south side between this tract and the Government tract on the south. The condition of our funds did not seem to permit this, and in addition to that, until we had some evidence of title it seemed undesirable to do. A plan has been discussed with Prof. Paddock and also with a representative of the Forestry Bureau at Washington, to whom plans were referred some time in the summer and their help invited. A man from the Bureau recently invited us, and Professor Paddock accompanied him to Akron to look over the ground and to reach some conclusion as to what was best to do. The negotiations with them has not gone further as yet, and to what extent they will be willing to aid in this work is as yet unknown. We hope that they may meet most of the expense, but while we so hope, it is unusual for them to aid financially to any extent. The total cost of carrying on this work is not, therefore, definitely ascertained. It would seem to require about $150 for 1908. In 1909, the tract would need to be fenced and some planting done so that apparently about $300 in 1909, besides fencing the tract on three sides, or a total of about $800 would be needed. Of this amount, in case the government aids, they might give one-half of the maintenance, but probably would pay nothing toward the fencing, so that the expense upon us would be from $700 to $900 in 1909. In 1910 probably $300

These figures are given not as estimates, but as a rough idea of the amount that would probably be required to continue the work. There is a possibility that the Forestry Bureau may act on the idea of forestry plantation there and plant trees on a portion of the land which has been turned over to the department and in that case it is a question whether it would be necessary or desirable to meet this expenditure and continue the work.

For the coming year, this would require then about $150, and this it would seem necessary for the Board to authorize. It is rather of a demonstrative character, does not fit in with the previous work of the Station, and is a doubtful charge on the Hatch fund.

I called attention to the general Plains situation in one of the previous reports. For a number of years we had a man at Cheyenne Wells. The result was negative. When the Government notified us that the Government funds could not be used for such purposes, we assigned Mr. Payne to work as general Field Agent and to note the conditions in a general way. This resulted in a number of bulletins and some were very valuable studies. They showed that there were possibilities

in the Plains as a whole and for individuals on the Plains. The work and the conclusions together with some recent favorable years have been made the basis of booming by some land speculators, and with the result that they have brought in many settlers on the Plains. The problem is there before us in that respect. They do not need investigations whose results are in the future so much as immediate advice as to how to meet the situation that is now before them. The most beneficial way of meeting the whole Plains is very largely, to meet people, to advise them, to learn the experience of those who have been there, and to make it available for those who have settled upon the Plains.

Many have gone upon the Plains with the hope of making farms and of using eastern crops, and eastern methods, and in some cases have risked their all. Many are bound to fail, even under the most favorable conditions. It is therefore a question whether it be possible to provide money which would permit the assignment of a man for that special work. Mr. Payne who has been an excellent man for such purposes, is now in the employment of the United States. Some arrangement might possibly be made, by which he could give some time to such work. In that case it might cost us from $700 to $1000, possibly less. Another course might be to provide a larger number of Institutes for the Plains. This, however, would involve the idea that we are prepared with the information and the experience necessary to give to those people, so that it will direct them right. This is ony partially true and the people who go on the Plains to advise the settlers as to the most hopeful way of meeting the situation, should have an extensive acquaintance, and therefore I think that it would be very desirable to have a man for that special purpose if it could be done. Mr. Payne has already acquired the experience through his connection with us. Since the time he was active, some conditions have changed on the Plains, and especially the situation in regard to the number of settlers. At that time there were relatively few, and a very few settlers coming in. Since then the number has greatly increased, and the need for work is very much greater.

THE FRUIT INVESTIGATIONS.

The Legislature made an appropriation for fruit investigations. This work was started on the solicitation of the people of Mesa County who provided $1,500. The State Board of Agriculture provided for an additional amount and put in last year, 1906, a total of about $4,000. The Legislature appropriated $8,000 for the biennial period. This is at a less rate than was expended last season. Hence we have had to practice economy. Some expenses necessary last year have not been necessary this year. The $4,000 per annum is scarcely enough as the pay of the two men amounts to $3,000. The appropriation for this purpose is treated differently from the appropriation for other purposes inasmuch as the salaries of the two men are taken from this appropriation. In

the case of the appropriation for Animal Industry, for Farm Machinery, and for Plant Industry, and for Farmers' Institutes the salaries of the men are not charged against the appropriation.

The position of Field Agent is one requiring good sense, and tact, as well as a desire to be of service. The work at Grand Junction has been especially satisfactory in this respect under the charge of Mr. Whipple and Mr. Taylor. Mr. Taylor resigned to take effect October 15, he having been appointed to take charge of the Fruit Experiment Station in Missouri. As his successor we have arranged to appoint Mr. George P. Weldon, As the margin is so small he will not begin until the first of February or the first of March. Under the conditions of the State appropriation and the financial limitations, it will doubtless be necessary to modify the plan for next year. Practically all of the work under this appropriation was performed in Mesa County. The bill, however, is general, and related to the fruit industry over the whole State. It will probably seem necessary to do more work during the coming year in some of the other counties, and probably therefore to leave one man at Grand Junction, the other to be placed at Delta. This seems the most feasible arrangement. From the standpoint of most effective work, it is desirable to concentrate the efforts in a limited area. In this case it is a question partly of expediency. I have already discussed the matter with Mr. Hoyt of Grand Junction who was particularly instrumental in the action of the Legislature, and with Mr. Moore, both active leaders. Mr. Hoyt thinks that we will have to do more in order to hold the support of the other fruit centers. Mr. Whipple now stationed at Grand Junction could also give more attention to Garfield and Eagle Counties. A horse and buggy have been provided. This has been the cause of considerable expense and has not been entirely satisfactory. It costs about $17 per month for keep, besides the repairs of the buggy and depreciation. The experience here and at Delta suggests that it may be better to allow an extra sum and have the men furnish their own transportation. A motor bicycle could probably be had for less than a horse and would do a greater amount of work. It would be desirable for the horse or equipment to be kept by the parties.

DELTA FRUIT INVESTIGATIONS.

A Committee from Delta appeared before the Board asking that some work be done in that county, and pledged $700 for that purpose. It was afterwards found that for some reason, some other centers had not been asked to contribute, and therefore there was some feeling of resentment. We have tried to reduce this and think we have succeeded. The total amount paid was $700. This was in addition to the salary for the time being, of Mr. Paull who was paid from the College funds. The work has had some other difficulties of its own. The fund still remaining will pay for the printing that may be necessary.

The general State appropriation also covers Delta County, and in

all probability the people of that County will not feel like subscribing for another season. We, however, ought to do what we can to help that community as above stated. The plan which would seem to be desirable would be to assign one of these two men to Delta as a headquarters, and make Delta and Montrose Counties his counties for work.

The establishing of these outlying centers of work is a matter of some delicacy. It requires men of scientific training who also are tactful and prudent, otherwise unless we could keep very closely in touch there is danger of great difficulties arising. The work has been appreciated but has also given rise to some difficulties and troubles that have been hard to allay. So far as the work consists in teaching the fruit men how to handle their fruit and insects, it would probably be of relatively short duration. The work ought, however, to be continued at one of those centers for a period of at least ten years. After the first few years, I am inclined to think that a change in plan might be desirable, but that will be a matter for future development.

THE POTATO WORK.

Last year there were some funds available for experimental work on potatoes This was put in charge of Mr. Bennett as potato specialist. His salary was taken care of by the Station funds, amounting to $1,500. There is no doubt that this work is of considerable use, something in the way the work of the fruit investigations is of value to Western Colorado.

A field was rented near Greeley, on the farm of one of the best known growers, Mr. Bliss. There will be about revenue enough from potatoes to pay for the cost of the land. The total expense otherwise involved has been about $600, including the cost of the printing. There was no money set aside for this last year, and we have crippled along allowing some from the special fund. For the coming year, I would recommend an appropriation of $750.

HORSE BREEDING WORK.

The cooperative work with the Government on horse breeding has been continued through the year. The outlay on the part of the College and Station in connection with it has been the barn, a considerable land, and other expenses. There is nothing in this office to show what the Government has put into the work. The Board is under obligation to expend the receipt in the work.

Other matters concerning the work of the various departments are mentioned to some extent in their reports. Most of the work of the Experiment Station is a kind of work that does not lend itself to any startling proceeding and is a quiet steady work, hence while there has been considerable important work, and there is now considerable going ahead, most of it comes under the ordinary procedure of the Station and along ordinary plans so that it does not make any particular comment necessary.

There have been printed during the calendar year so far, nine bulletins, besides eighteen press bulletins. The editions now will need to be increased from 8,000 to at least 12,000 to 15,000, doubling the cost. With the increase it may be necessary, or at least desirable for us to do as some other stations have done, and that is to issue a popular or printed edition which will give a summary of results of the bulletin and then send the larger bulletin on request. One of the most important and laborious studies is Bulletin 124, on Colorado Fodders, giving the results of a number of years' work. Such a one will not have any immediate effect, but represents much work directed along a particular line, and its value becomes more apparent as a foundation of subsequent practice. A number of other bulletins are soon to be ready to issue. The state of the funds has made it necessary to hold back bulletins or not to hasten them and hence it is probable that a number will be issued in the near future.

Our printing bill the last fiscal year was larger than usual, but in the years to come, it will probably be nearly as large. The size was partly due to the payment of some of the expenses of Bulletin 100. In some states, the expense of printing is paid out of other funds and is not put in as a charge on the Hatch fund. The work may be done by the State printer and the laws are such that it is paid for by the State. The fact that we have to meet these bills lowers the efficiency of the Hatch fund On the other hand, considerable help is given from College funds in that heating and janitor service is almost entirely at College expense. The other funds make it possible to divide the proportions more easily and during the present fiscal year, several of the men who give a large part of their time to the Station receive one-half or more of their pay from the Government funds.

The financial statement and reports of the various sections form a part of this report.

L. G. CARPENTER,
Director.

Dec. 1907.

BULLETINS ISSUED DURING YEAR OF 1907.

No. 117. The Colorado Potato Industry, by E. R. Bennett.

No. 118. Western Slope Fruit Investigation, 1906. Report of Field Horticulturist, by O. B. Whipple.

No. 119. Western Slope Fruit Investigation, 1906. Report of Field Entomologist, by E. P. Taylor.

No. 120. The Howard Scale, by E. P. Taylor.

No. 121. Alfalfa, Sugar Beets, Cantaloupes, Notes 1906, by P. K. Blinn.

No. 122. Fruit Growers' Associations, by W. Paddock.

No. 123. Some Press Bulletins on the Plains.

No. 124. Colorado Fodders, An Examination into their composition and Comparative Values, by W. P. Headden.

No. 125. Colorado Fodders, A Study of Comparative Values based on Bulletin 124, by W. P. Headden.

PRESS BULLETINS.

No. 29. Cost of Colorado Roads, by E. B. House.

No. 30. The Howard Scale, by E. P. Taylor.

No. 31. The Green Aphis and the Woolly Aphis of the Apple, by C. P. Gillette.

No. 32. The Locust Borer, by C. P. Gillette.

No. 33. Dairy Work for Plains Settlers, by H. M. Cottrell.

No. 34. Acclimated Seeds, Hints for New Settlers in Eastern Colorado, by W. H. Olin.

No. 35. Wind-Breaks and Shelter Belts for the Plains, by B. O. Longyear.

No. 36. Preparation of Seed Bed, Hints for the Plains, by W. H. Olin.

No. 37. Potatoes on the Plains, Suggestions to New Settlers, by E. R. Bennett.

No. 38. Grasshoppers Upon The Plains, by C. P. Gillette.

No. 39. Summer Culture to Conserve Moisture, Hints for Plains Settlers, by W. H. Olin.

No. 40. Seeding Field Peas, by W. H. Olin.

No. 41. Pruning Locust and Catalpa Trees for Timber, by B. O. Longyear.

No. 42. Western Slope Fruit Investigation. Condensed Report of Field Entomologist, Season of 1906, by E. P. Taylor.

No. 43 Western Slope Fruit Investigation. Report of Field Horticulturist, by O. B. Whipple.

No. 44 Spraying for Codling Moth, Some Important Points to be considered. by C. P. Gillette.

No. 45. The Spring Grain-Louse, by C. P. Gillette.

No. 46. Advice to Plains Settlers, by J. E. Payne.

REPORT OF CHEMIST

To the Director:

I herewith present a statement of the work of the Chemical Section during the period elapsing since my last annual report.

The work on our Colorado fodders has been completed and our results presented in Bulletin No. 124, issued in July last.

The work on the Australian saltbush, *Atriplex semibaccata,* and Russian Thistle mentioned in my last annual report, as nearly completed, was prosecuted to the extent of completing the chemical work on the samples of these plants which I had up to that time collected and I gathered my notes for the preparation of a small bulletin on their composition and value. I, at that time, thought that this Australian saltbush had been studied and its coefficients of digestion determined by the California Experiment Station, and probably also under the direction of the Australian authorities, but I was unable to find such data. Inquiry addressed to the Office of Experiment Stations at Washington, D. C., resulted in obtaining the information that no determination of the coefficients of digestion of this plant was known to that office. It, therefore, seemed to me desirable that these data should be definitely established before we presented this plant to the consideration of our people as a forage plant. But to make a single series of digestion experiments meant, in this case, to grow fodder to be fed and to postpone the preparation of the manuscript practically a year or rather more.

The crop has been grown, but owing to a number of untoward happenings, I fear that we may be necessitated to grow still another crop before we can complete the work but I sincerely hope that such may not prove to be the case. In this connection I wish to acknowledge the willing and interested assistance rendered by Mr. Knorr and his student assistant, Mr. Aicher, to whom is due the credit of our having any crop at all.

The reasons for undertaking this study were given in my last report. Originally, I began growing the plant in order to make a study of it, but as I, at that time, about nine years ago, judged it doubtful whether it would ever become a plant of sufficient importance to any section of this State to justify its cultivation as a fodder plant, I permitted other work to take precedence. But I fear as the eastern portion of our State fills up with settlers, occasion may arise when this plant, owing to its tenacity of life and ability to make a fair growth under adverse soil conditions might be a great boon to them. I propose now to return to my original plan of presenting a short study of

the plant which will be of more general interest than a mere presentation of its manner of growth, cultural needs, etc.

There have been times in the eastern portions of our State when any kind of fodder would have been of great service in tiding stock over a period of severe weather but fodder was very scarce and stock perished from lack of it. Perhaps our increased knowledge and improved methods of cultivation may have removed this danger, still I believe that if it can be shown that the Australian saltbush has a reasonable amount of merit, it will commend itself as a forage for this large section greatly to be preferred to the sand grass, Russian thistle or hay made from the silvery saltbush hays which I know that they have had recourse to in order to keep their stock.

I shall include a short study of the Russian thistle but no digestion experiments. This hay is used to some extent in some parts of the State. Its value is doubtful, though some claim that it is good.

I began the collection of alkalies from this State shortly after I became connected with this Station, thinking at that time that there was probably a big basis of fact underlying the then current public notion that it was an important factor and a growing one which promised to become more deleterious to their lands and crops than it was then. I soon became convinced that the evil effects attriubted to these salts and the impending danger due to their apparent increase was greatly overestimated, and as but little satisfactory information was being accumulated, I have not prosecuted the study of the subject except as opportune occasions have presented themselves until within the last year. There are some questions of interest and prossibly of importance in connection with this question, particularly as it relates to drainage, and the use of water carrying considerable quantities of these salts for the purpose of irrigating crops. Again, some lands in our irrigated sections are becoming seeped and pari passu alkalized and it is a question whether the latter effect intensifies the former or not, and further whether the correction of the former will of itself remove the effects of the latter.

During the present season, I have turned my attention quite exclusively to the study of this subject—to some extent in the neighborhood of Fort Collins and Greeley, but to a greater extent in the San Luis Valley, and in the neighborhood of Delta and Grand Junction. Some of the results of this study will have some scientific interest, others will have quite an important economic bearing.

I proposed to take up the study of the water of the Rio Grande del Norte with the intention of studying the changes in its mineral content and their variation in composition as effected by the irrigation of the surrounding lands. I proceeded to the town of Creede with my assistant, Mr. Douglass, intending to begin the study of the water above the point where the Willow Creek joins the Rio Grande. We found the river unusually high and devoted ourselves to the study of the questions pertaining to the seepage and alkali, hoping that the

river in the meantime would fall to its usual stage at this season of the year. Our work consumed over three weeks but the river had not fallen, due to the succession of showers in the mountains and also in the valley. Determinations of the mineral matters in the river water near Creede and three weeks later at Alamosa showed a difference of only abuot two grains per gallon. This result showed that it would be futile for us to prosecute this work under these conditions with any hope of obtaining results which would certainly represent normal conditions. Data which I have already collected relative to the changes in the Rio Grande waters indicate that they are much less than in our northern streams, but I believe them to be normally much greater than indicated by the determinations alluded to and I therefore did not venture to prosecute the work.

I have, up to the present, found no opportunity to approach the subject of mountain or meadow irrigation and a study of the composition of the fodders produced. I furthermore, do not see how I can possibly begin this work for some time to come as the already accumulated analytical work is very considerable.

Mr. Alford has revised the manuscript presenting the results of his experiments with beeswax.

The work on the loss and deterioration of barnyard manure under our conditions came to an abrupt end by the interference of Mr. Montgomery, who needing a load of manure, appropriated ours, utterly spoiling the lot for our further use. Mr. Douglass is preparing an account of the work done. The record covers a period of four years, but only the weights for three years can be used. This interference is very much to be regretted as it rendered our fourth year's work of little value. In the beginning it was intended to study the bacteriology of the pile, but this feature has had to be dispensed with, so our results will present only the loss and changes in its chemical composition. Mr. Douglass will not be able to work consecutivaly upon his manuscript and its preparation will necessarily be slow. It will not be ready before the late summer or more probably the fall of 1908.

It now seems probable that the next bulletin which I will present will be on the Australian saltbush, *A. semibaccata*, and the Russian Thistle, followed by one on the alkalies of Colorado which will include a study relative to use of seepage water for purposes of irrigation.

The analytical work still to be done on these subjects will not permit me to even suggest how soon or how long it may be before I can present them for publication.

So far as our present work is concerned, we need nothing of sufficient importance to deserve mention in an annual report.

The requests for analytical work of a miscellaneous sort, largely waters and soils, continue to be numerous. It is clearly out of the question, with our present force, to do any of this kind of work especially in cases where the request is made by an individual, and where the work can in no reasonable way be made to serve any purpose for the Station. This Section is always ready and willing to give such

information as may be at its command but I have accepted very little of this class of work. I may add further that I would be unable to give the specific information requested in almost all of the cases even if I should have the soils or water analyzed, and in no case which I now recall would any scientific purpose be served.

Respectfully submitted,

WM. P. HEADDEN,
Chemist.

Fort Collins, Colo., Dec. 1, 1907.

REPORT OF ENTOMOLOGIST

To the Director:

I have the honor to present the following report of progress in entomological work supported by the Hatch fund for the year 1907.

During the year bulletins 119, "Report of Field Entomologist of Western Slope Fruit Investigations" and 120, "The Howard Scale," both by E. P. Taylor, and press bulletins, 31, "Green Aphis and Woolly Aphis of the Apple;" 32, "The Locust Borer;" 44, "Spraying for the Codling Moth;" and 45, "The Spring Grain Louse" have been published A technical paper upon plant lice entitled "Chermes of Colorado Conifers" has been published in the Philadelphia Acadmy of Sciences, a similar paper describing a new louse upon cottonwood is about to appear in Entomological News, and descriptions of several new species of plant lice (Aphididae) that have been discovered in the prosecution of our work with this group of insects have been sent to the Canadian Entomologist for publication along with life history notes of the species. While the more technical papers have been sent to technical journals, the economic deductions from these studies will be given to the farmers and fruit growers from time to time in Station bulletins.

SOME OF THE MORE IMPORTANT INSECTS OF THE YEAR.

The very mild winter of 1906-7 permitted many plant lice to survive the cold and start their spring broods in unusually large numbers. As a consequence the spring Grain Louse, *Toxoptera graminum*, was destructively abundant in many grain fields in eastern Colorado, and the wolly aphis of the apple trees was extremely abundant early in the season and, where it was not destroyed by sprays or overcome by its natural enemies it remained a serious pest throughout the season. In regard to the latter pest I am glad to say that our experiments carried on chiefly on the Western Slope, as well as the experience of many orchardists, has proven that kerosene emulsions or tobacco preparations can be used very effectively to destroy this louse upon the trees. The plant lice have become such serious pests in the State that it has been thought best to give them special attention and many species have been collected and observations recorded upon life habits and food plants during the year. This work will be a valuable supplement to the plant louse investigations carried on under the Adams fund.

The Spotted lister Beetle, *Epicauta maculata,* was sent to the

station this past summer from the eastern part of Arapahoe county as a serious pest in potato fields. Arsenical poisons were recommended and Mr. E. G. Sanderson reported very good results from the use of Paris green as a spray.

The Western Wheat Stem Maggot, *Pegomvia cerealis,* which the writer reported in 1904 (Bulletin 94, Colo. Experiment Station) as destructive to a field of wheat near Fort Collins was sent to the station from Littleton and from Cortez as a wheat enemy the past spring during the month of April. This is doubtless a native insect as it seems not to be known outside the state.

The Onion Thrips, *Thrips tabaci,* occasioned considerable loss to onion growers, especially in the vicinity of Greeley, during the latter part of the summer and an effort was made to assist them in finding a practical remedy, Mr. S. A. Johnson making two trips to the district for that purpose.

Mr. D. B. Thurston, horticultural inspector for Boulder county, sent the station specimens of the peach borer, *Sannanoidea exitiosa,* which he reported very destructive to plum, apricot and cherry trees in the vicinity of Boulder. Mr. L. C. Bragg was sent to investigate the conditions and he found this borer quite abundant and actually killing many small cherry trees.

An experimental orchard of nearly 1,000 trees was set in the spring for plant louse experiments chiefly. The entomological garden has been in charge of Mr. Johnson who has found it a very favorable place to study garden pests., his chief attention having been given to the spotted bean beetle, *Epilachna corrupta,* and the potato Flea Beetle, *Epitrix cucumeris.*

The black peach aphis, *Aphis persicae-niger,* has been known to exist upon very few trees only upon the Western Slope for two or three years, but during last spring and the early summer Mr. E. P. Taylor of the Western Slope Fruit Investigations found this louse in many orchards in the Grand Valley and in a few in Delta county. While for a time the lice became quite abundant early in the season they soon dissapeared and did not seem to do much serious harm.

WESTERN SLOPE WORK.

Mr. E. P. Taylor of the Western Slope Fruit Investigations has devoted his attention especially to the control of the wooly aphis, (*Schizoneura lanigera*) and the green apple aphis, (*Aphis mali*) but he has also sent in much important information concerning other insect pests in Western Colorado. His very complete and detailed repot is appended hereto.*

There were two general heads under which research work was taken up, one a biological and taxinomic study of Colorado Aphididae (plant lice), and the other a biological and economic study of the potato flea beetle, (*Epitrix cucumeris* Harr.) The latter study has

* The report of Mr. Taylor details observations made during the year. Being too long to print, it is put on file in the records of the Experiment Station.

been entirely in charge of Mr. S. Arthur Johnson while the former has been in charge of the writer with the assistance of Mr. L. C. Bragg and the department artist, Miss M. A. Palmer. Mr. E. P. Taylor, Field Entomologist for the Western Slope Fruit Investigations, has also collected and made field notes upon numerous species for me.

The three species selected for special study are the Wolly Aphis of the Apple (*Schizoneura lanigera*), the Green Aphis of the Apple (*Aphis mali*), and the Melon Louse (*Aphis Gossvoii*).

As a necessary basis for this work we have endeavored the past year to determine as fully as possible, the food plants of all our common species, and the time of the year when the different species may be found upon their various food plants, and to make careful descriptions of the living lice in their various stages of development. This has required a large amount of field and breeding cage as well as taxonomic work. In connection with the descriptive work the department artist has made careful detailed drawings in color of the lice in their different forms and stages of development.

A few technical papers resulting from the above studies have been sent to scientific journals for publication and others are in preparation. The economic deductions will appear in station bulletins.

The assistance rendered Mr L. C. Bragg and Miss M. A. Palmer in the plant louse work has been most important and efficient.

The work of Mr. Johnson upon the potato flea-beetle will be written up for publication as a station bulletin soon.

The new insectary just being completed will be a great assistance in carrying on future work with these insects.

I am appending an invoice of the property held by this Section that has been purchased by money from the Adams fund.

All of which is very respectfully submitted.

C. P. GILLETTE,
Entomologist.

REPORT OF THE HORTICULTURIST AND BOTANIST

To the Director:

The report of the horticultural section will consist mainly of the sub-reports from the men who have had charge of special lines of work.

The schedule submitted to you at the beginning of the year has been adhered to closely though but little has been acomplished with some of the lines of work; namely, those with which I personally had to do. The reason for this is that the growth of the section both in the college and station requires a great deal of attention as to details. This is particularly true in the extension work which the college is now carrying on.

The experiments with alfalfa blight have not progressed except that we succeeded in securing about thirty strains of seed from the Department of Agriculture and planted them in an infected field. The seeds came up promptly and the plants have made an excellent growth.

The work with tomato blight has been carried far enough to show pretty conclusively that instead of being a new disease, the trouble is due to attacks of a species of Fusarium. This is probably the same species which has been common for several years in various portions of the United States.

The root disease of raspberries has not been worked upon because of lack of time.

The field work in horticulture on the Western Slope continues to be one of our most practical lines. This feature was broadened this year by stationing Professor Paull in Delta county for the season. That there is an increasing demand for this class of help and that much good may be accomplished by it is clearly shown in his report. We hope that this experience may result in placing a man permenantly in that locality.

The potato investigations are now well under way and the problems are developing to such an extent that one man can scarcely keep abreast of them. The experiments now being carried on give promise of valuable results.

Our experiments in forestry have been confined to the tree plantations which have been noted in former reports. The subject of forestry is one of such vital importance that means should be provided so that a man could devote his entire time to these problems.

Respectfully submitted,

W. PADDOCK,

Horticulturist and Botanist.

Fort Collins, Colorado,
December 1, 1907.

REPORT OF ASSISTANT BOTANIST.

During the summer just past my time has been chiefly devoted to the inspection of the cooperative tree planting experiments in my charge, which were inaugurated during the spring of 1906. These experiments consisted in supplying farmers and land owners in various localities with two species of trees to be planted and cared for under the direction of the experiment station. Black locust and the hardy or Western catalpa were selected on account of their general utility qualities, and so far as possible, 300 trees of each kind were sent to one person.

The data secured from these experiments should enable us to make recommendations concerning these trees for planting under most of the conditions occurring in our state. And while it is yet too early to estimate the reliability of the trees under all circumstances still the prospect is in most cases encouraging.

Out of the twenty localities visited fifteen were favorable for the growing of the black locust. The catalpa was not sent to all of these places but made a fair comparative showing in most localities where planted.

In the majority of cases the black locust made the stronger growth and showed somewhat greater hardiness than the catalpa.

Remarkably strong growths of the former were noted in some places where the trees had been given good soil and care.

In a number of cases due to lack of care or poor location the trees failed when the climatic conditions were evidently not unfavorable to their growth. And it was often a source of surprise to see how tenaceous these trees were under the trying conditions in which they were sometimes found.

It may be safely stated from the observations made, that with reasonable care in planting and watering these two species of trees should succeed in situations similar to those in the region of Denver while the black locust is doing well at elevations considerably higher.

Nearly three weeks were spent in the study of our native forest trees in the Long's Peak region. Photographs and data were secured toward the publication of a bulletin on the cone bearing trees which constitute the native timber supply and the forest trees of our forest reserves in this state.

Respectfully submitted,

B. O. LONGYEAR,

Fort Collins, Colo.
Dec. 1, 1907.

REPORT OF POTATO INVESTIGATIONS.

The potato investigation work is being carried on along practically the same lines as last year. The aim of the work is as follows:

First; to improve the industry by a study of the best methods of culture of potatoes for this state. Second, to improve the quality and yield of the present varieties by selection. Third, a test of the standard varieties to find if possible a variety that will be resistant to the soil diseases that cause the losses of the potato crop of this state. Fourth, to study systematically the diseases of potatoes of this region. Fifth, to bring this knowledge to the growers by means of publications and lectures or talks with individuals.

Owing to the nature of the work all these objective points are taken up together.

NEED OF THE WORK.

The yield of potatoes of Colorado is from six to eight million bushels per year as against three hundred million for the United States.

The markets for the Colorado potatoes extend over more than half of the United States. The soil and climatic conditions of a large part of Colorado are such that when no disease prevails no part of the United States, except possibly Northern Maine, can produce potatoes of such quality or a better yield. Some localities in the state produce from four to six hundred bushels per acre, yet there are so many failures or partial failures in the crop that the average yield per acre for the state (Bureau of Statistics, U. S. Department of Agriculture) is less than one hundred bushels, or fifty sacks. A general survey of the state shows that there is available land that is adapted to the best potato growing to produce five or six times as many potatoes as it now produces.

The work of selection is being carried on by this writer in several parts of the state and also in cooperation with some of the best growers in several districts.

One and fifty-five hundredths acres of land were rented on the E. R. Bliss ranch at Greeley on which were planted seventy-six varieties and a quantity of seedlings. Among the varieties were some of the standard French, German, Russian and Scotch market varieties, also some alcohol potatoes from Germany. A large number of these varieties made good yields and crates of each have been selected for use next season. Almost no disease appeared in these plots so no data could be taken as to the disease resistance of the different varieties.

A plot of about one acre of potatoes was planted on the college farm for the purpose of studying diseases and the effects of different methods of cultivation and seed treatment.

Only one variety was used on this plot. The seed was divided and part cut while the remainder was planted whole. The cut seed was divided and treated respectively with dry sulphur, air slaked lime, dry Bordeaux, and a part left untreated.

DISEASES OF POTATOES.

Potatoes have been less troubled by the fungus diseases this past season than the year previous.

Fusarium:—Soon after planting this season a rot developed in the pieces of seed potatoes. The rot started on the cut surface of the seed and worked through to the skin. Some rotted so quickly that the sprouts did not start at all. Others rotted more slowly so that the sprouts emerged from the ground but soon died because of the rot following up the stem from the seed. An examination of these stems and rotting tubers showed the presence of a fungus which is supposed to be Fusarium solani.

A poor stand resulted from this disease, especially on land that had been in potatoes the previous year. Microscopical examination of plants were made at intervals all summer but while the fungus could be found during the whole season, little damage was done by it during the latter part of the season except in a few localities.

Comparatively little is known of this disease at present. Work on it is being done and will be continued during the winter in the greenhouse and laboratory.

Rhizoctonia:—The Rhizoctonia, or stem and root rust disease, did much less damage in the state than in previous years. Places where the soil was hard and compact or basins where water settled were the only places troubled seriously by this fungus.

Work with this disease is going on in the laboratory and greenhouse. Potatoes grown in the greenhouse under sterile conditions and inoculated with Rhizoctonia produced scabby potatoes as well as the Sclerocia or resting stage of the fungus.

The subject of scab from other sources is being also studied. German botanists claim that scab on potatoes may be caused by several different fungi. Cultures of the fungus that is supposed to cause the scab of the eastern states have been obtained and will be used to inoculate growing potatoes in the greenhouse this winter.

EXTENSION WORK.

Considerable time has been spent during the past season in investigating the conditions and talking at institutes in different parts of the State. In the opinion of the writer this work is desirable, especially in the newer parts of the State, where the knowledge of cultural methods and varieties best adapted to the conditions is limited.

Respectfully submitted,

E. R. BENNETT.

Fort Collins, Colo.,
Dec. 1, 1907.

WESTERN SLOPE FRUIT INVESTIGATIONS.

Report of Field Horticulturist.

The work of the field horticulturist during the past year has been along the lines suggested in my report for 1906. Practically all of my time has been devoted to Mesa County. Investigations of plant diseases, cultural methods, handling irrigation water, pruning and the collection of data on the fruit industry in Mesa County has largely occupied my time.

In the work we still have the hearty cooperation of the fruit growers. Requests for information have been more numerous and orchards and vineyards have been freely placed at our disposal for experimental purposes. The work is beginning to show more definite results as time passes.

The orchard survey work has progressed during the year as time would permit. The county has not been covered by any means, but other work of more immediate importance seems to require the time that should be devoted to this work.

The plant diseases under observation have been largely those mentioned in my last report. Very few new troubles have appeared although some of the diseases found last year have apparently assumed more importance.

The loss of grapes from the attacks of powdery mildew called for experimental work in the control of this disease. Experiments were outlined in the use of Bordeaux mixture and powdered sulfur in this fungus. Results of these experiments and observations in other vineyards show that the fungus is most easily controlled by the use of sulfur. Two dustings, one just as growth is starting and one after the fruit has set, seem to be sufficient.

Peach mildew again appeared in a few orchards and presented the opportunity for demonstration work in the control of this fungus. Experiments undertaken in a badly infected orchard only go to prove more conclusively that such an orchard can be thoroughly cleaned up with one careful spraying with half strength Bordeaux mixture.

Pear blight has caused some serious loss and many neglected orchards are practically gone. It has also caused much anxiety by attacking some apparently well cared for orchards.

The root rots are seemingly gaining some headway in the destruction of some varieties of apples. An effort was made to show the effectiveness of treating affected trees by cutting away the diseased bark, and washing the wound with a disinfectant. The results of

this work were very discouraging, and in fact almost demonstrated that such a practice means only failure. The use of lime about the base of the tree, as a preventative measure, was also tried and seems worthy of a more thorough test.

Some other plant diseases of minor importance found during the year are powdery mildew of the apple, powdery mildew of the squash and cantaloupe and the Fusarium wilt of the cantaloupe.

Some experiments were undertaken in cross pollenation of apples but on account of many of the blossoms being lost by the frost this work will hardly give any reliable results.

It is gratifying to note that the growers are heeding the instructions of the Experiment Station staff in the more careful use of water and the handling of various types of orchard soils.

Respectfully submitted,

O. B. WHIPPLE,

Grand Junction, Colo.,
Nov. 1, 1907.

REPORT OF THE DELTA COUNTY FRUIT INVESTIGATION.

April 24 to September 5, 1907.

At the request of a committee of fruit growers from Delta County, I was assigned to this work which was prosecuted between the above dates.

The nature of the work was primarily two-fold; first, so far as possible, to give advice and aid to the fruit growers upon any line in connection with their work; second, to collect information on all matters pertaining to horticultural interests.

To the people of the County the success of the investigation is measured entirely by the results obtained under the first class; because of its fundamental and lasting character, forms the superior basis for judging of the value of such work. However, in this class the observations of one season are of but slight value of and by themselves, but must be repeated through successive seasons to test their accuracy and finality. It is because the practical fruit grower or farmer judges things mainly by immediate results, whereas the horticulturist foresees that the basis of correct practices lie in the slow and laborious collection of data from observation and experiment, that both of these lines of work are essential in such an investigation.

The work naturally divided itself into several lines in each of these classes, in fact, in most cases being common to both.

A discussion of a few of the problems attacked follows:

ENTOMOLOGICAL WORK.

The most of my efforts along this line were directed to the carrying out of a series of spraying experiments against the Green and the Woolly Aphis of the apple, by far the most serious insect pests of the year. One large grower offered to place at my disposal his orchard and to furnish labor and materials if I would direct the experiments. Comparative tests of many different sprays and combinations resulted in determining that a strong tobacco extract, applied with or without soap, at a high pressure, in proportions from 1 to 80 to 1 to 65 was by far the most efficient summer spray for these pests and that they may be very well controlled by this method.

SMUDGING AS A MEANS OF FROST PROTECTION.

Here, as elsewhere in the State, there occurred great losses to the fruit crop by successive freezes in April and early May. Following the example of the Grand Valley some attempts were made to smudge, using baled hay. Believing this to be too expensive a material for the

amount of smoke obtained, I set about finding a material which should combine ease of handling and storage, maximum smoke-producing power and low cost. This was secured in a compound of sawdust, gas-tar and crude oil, in which the sawdust forms the base, the gas-tar a binding material, and both gas-tar and oil throw thick black smoke. It is believed that this can be made at about one-half the cost of the hay, and moulded into blocks by hydraulic pressure for ease in handling and storing. In an actual orchard test upon one acre the temperature was raised from 5 to 7 degrees in different parts of the area. This would have saved the crop in the spring. There is a likelihood of a company being formed to manufacture this material in the County.

SOIL AND DRAINAGE PROBLEMS.

These problems are unique in this County and little understood. The few drainage systems thus far installed are not very satisfactory. Believing that great value would result from a soil survey, I placed in circulation a petition to the U. S. Bureau of Soils and secured more than 200 signers among the property owners in various parts of the County. This is on the way to Washington, and it is hoped will result, in a thorough survey at an early date. I also succeeded in interesting the Division of Drainage and Irrigation Investigations of the Office of Experiment Stations, U. S. Department of Agriculture, in the problem of drainage, and they sent an engineer who spent about a week looking over the ground. As a result they will later on locate an engineer in the County to conduct cooperative drainage experiments with the farmers and fruit growers there.

Considerable advice was given concerning methods of control of plant diseases, the use of water in the orchard, cover crops, etc., which seemed to meet with general approval. Altogether it appears that the work of the season was valuable far beyond its cost and if possiible should be continued.

Respectfully submitted,

L. F. PAULL,

Dec. 1, 1907.

REPORT OF AGRICULTURIST

To the Director:

I take pleasure in submitting herewith brief reports from the animal husbandry, farm mechanics, agronomy and horse breeding divisions of the Agricultural Department of the Experiment Station.

I regret very much that the work that we have been enabled to accomplish for the past season has been so unsatisfactory and so limited in extent in this Department. The reason for this condition may be found, however, in the fact that the funds provided for research work in this Department are practically all obtained from special state appropriations. These appropriations as made by the last legislature were liberal and had they been made available early in the year when we expected they would be, we should have had a very much different report to make. As it was, however, we had no funds other than those that were advanced by you from other funds from time to time to carry on absolutely necessary work until the month of October of this year, when the state appropriation funds were turned over. Consequently no experiment work whatever was undertaken in the animal husbandry division other than to carry over some steers on pasturage. The work in the agronomy division was curtailed and limited owing to the uncertainty of our funds being adequate to carry on any extended lines.

In the farm mechanics division we were also compelled to lie perfectly idle during the summer months because of no funds being available.

We earnestly hope that some provision may be made in some way for the future whereby we can have some funds set aside definitely for these different divisions, that may be made available early in the year. Our appropriations as now made, are for the biennial period and as I understand it, cannot be used after the close of the said period except in small amounts. Consequently, all or nearly all of the state appropriations must be utilized in one year of the biennial period. Nearly all of our research work, in order to be of real merit, must be continued from year to year without interruption.

I understand that eighty per cent of the first part of the appropriations made for the biennial period is now available. It will be useful for the feeding experiments in animal husbandry work this winter, but comes too late, however, to be of any especial service for the agronomy and farm mechanics divisions.

The accompanying report of the animal husbandry division outlines the feeding experiments proposed and now under way for the coming winter.

The work carried on last winter was not sufficiently conclusive to warrant us in publishing the results. Consequently they have been witheld for further verification during the coming winter. I take this opportunity, however, to present a summary of the data obtained from the hog feeding experiment conducted last winter. This will be fully elaborated and published early in the coming year together with that from the experiment along similar lines that is now under way.

EXPERIMENT WITH 100 PIGS IN 10 LOTS OF 10 PIGS EACH FOR 102 DAYS, FEBRUARY 2 TO MAY 15, 1907. ALL GRAIN ESTIMATED AT 80 CENTS PER CWT. ALFALFA AND BEETS AT $5.00 PER TON. TANKAGE $30 PER TON.

Lot	Kind of Feed	Total Amount of Feed	Total Gain, 10 Pigs	Average Daily Feed	Ave. Gain per Pig per Day	Amt. Feed for 100 lbs Gain	Total Cost of Feed	Cost, 100 lbs Gain	Profit, 10 Pigs
1	Barley	6083		5.96	1.23	4.86			
	Alfalfa	918	1251	.9		.73	$50.95	$4.07	$30.36
2	Corn	6557		6.42		4.62			
	Alfalfa	998	1358	.97	1.33	.73	54.95	4.04	33.32
3	Barley	3347							
	Corn	3347		6.36		4.28			
	Alfalfa	998	1514	.97	1.49	.65	54.45	3.59	43.96
4	Barley	3110							
	Wheat	3110	1378	6.09	1.35	4.51	49.76	3.61	39.81
5	Barley	3133							
	Peas	3133	1382	6.15	1.36	4.52	50.02	3.61	39.90
6	Barley	3129	1399						
	Shorts	3129		6.13	1.37	4.47	50.06	3.56	40.87
7	Barley	6065							
	Tankage	718	1552	6.65	1.52	4.37	59.29	3.82	41.59
8	Corn	6345							
	Tankage	718	1686	6.92	1.65	4.18	61.35	3.65	48.06
9	Barley	5199				4.61			
	Beets	5348	1127	5.09	1.1	4.75	54.95	4.87	18.31
10	Corn	5354		5.24		5.42			
	Beets	5348	987	5.24	.97	5.42	56.20	5.7	7.95

The report from the agronomy division herewith submitted, outlines a very extensive series of investigations that we have undertaken in a tentative sort of a way, though they have never been definitely approved, nor has any portion of the Adams fund been set aside, so far as I know, for their conduct. We have been very loath to undertake

some of these lines while basing our hope for future support entirely upon the state legislature. If these lines of research are undertaken we should have the assurance that they are to be carried through for a period of years without interruption. Otherwise, there would be no use in beginning them.

The work undertaken has been very carefully followed out by Professor Olin and his assistant, Mr. Knorr. Their report very briefly outlines the work accomplished.

HORSE BREEDING.

In the horse breeding division, there has been a steady progress made in the investigations and demonstration work. A number of valuable animals have been contributed to the breeding stud by friends interested in the work. One of the most valuable of these has been received from Ex-Governor Alva Adams. The terms on which this animal was received from Mr. Adams were that the first foal from this mare by Carmon is to be returned to Mr. Adams at weaning time without expense to him. After that, the ownership of the mare is to be ours unconditionally as well as all future produce. Another valuable animal has been donated by Mr. John Kuykendall, of Denver. This mare had a young colt at foot when received, in which Mr. Kuykendall wishes to retain one-half interest. This mare was bred to the stallion Emigrant, owned by Mr. G. W. Rainsford, of Diamond, Wyoming. We were very fortunate in having her bred to this stallion, as he is now 24 years old, and, as he has sired several of our best brood mares, we are hoping that we may succeed in receiving a good foal from him by the mare donated to us by Mr. Kuykendall.

During the year, two additional mares have been added to the stud by the Department of Agriculture through purchase. One of them is a particularly good one and the other fair, though exceptionally well bred. A number of mares did not prove in foal and several of them were very late in dropping their foals. Consequently, we have but 17 foals for the year 1907. With one or two exceptions, these are all very promising.

The foals from the year 1906 have developed into exceptionally promising yearlings. Of the six stallion foals, of last year, four were castrated early in the spring, as they were not deemed of sufficient promise to preserve for breeding purposes. The two remaining ones are very promising indeed as future stallions for breeding purposes. The eight mares with two or three exceptions are good individuals and will be a great addition to our stock of brood mares in the experiment. I feel very confident that the results of our work in fixing the type of an American carriage horse is going to fully equal our expectations. One of the greatest problems in this work is now in a fair way of being successfully solved, viz., that the type we have selected may be perpetuated in the offspring. This seems to have been fairly effectually demonstrated in the two crops of colts now on the College farm.

THE NEEDS FOR THE FUTURE DEVELOPMENT OF THE HORSE BREEDING WORK.

The last state legislature made an appropriation of $5,000 for the conduct of this experiment. Of this amount, $1,000 has been utilized in the purchase of additional pasture land. It will require $2,000 of the remaining portion for the construction of shelter for the brood mares and the young stock. Also in the construction of suitable fences about the small fields and corrals that are very much needed at the present time. We are planning to locate one of these sheds out in the foothills pasture where the mares will have abundance of exercise during the winter months and where they can be fed a certain amount of hay in this shed when it is desired. The other shed will be constructed on the farm adjacent to the present horse stables and will be utilized for the shelter of the young stock and possibly some of the brood mares when it is necessary to keep them where they can be more closely supervised than when in the foothills pasture.

It is hoped that the Agricultural Department will soon add a few choice mares and an additional stallion to the stud. These are very much desired, particularly the stallion, as a number of Carmen's female colts will soon have to be bred and a suitable horse should be obtained with which to breed them. Three or four of the present stock of brood mares have not proven to possess any great merit as breeders and they should be disposed of while it can be done to advantage. It is our plan at present to take the young stock that we do not believe is desirable to keep in the experiment and thoroughly train them and then dispose of them to the best advantage, financially and otherwise. As the funds from the sale of this stock reverts to the experiment fund, this money may be used in financing the work of the future.

Much interest is being manifested not only in the West but throughout the United States in the outcome of this experiment. The correspondence coming to my office making inquiries concerning the success of the undertaking exhibits a very lively interest indeed. Already have there been a number of breeding establishments started along similar lines to the one undertaken here and an organization has been perfected in the East among the American Trotting horse breeders for the encouragement of the American carriage horse. At a number of the large state fairs of the Middle West classes were established this year for this type of horses and liberal premiums were offered. I feel very safe in saying that no work that we have ever undertaken could have redounded more to our credit as an institution of research and demonstration than this one of developing an American type of horses. Plans have been perfected by the Government cooperating with other Experiment Stations in developing and encouraging them to take up similar lines of work with other breeds of live stock. In Minnesota the Department is cooperating with the Experiment Station in developing milking types of Shorthorn cattle,

while in Wyoming plans have been matured for the development of a type of sheep suitable for the range conditions. In Iowa the work of developing a draft horse suited to our conditions has been undertaken. All of these efforts have been the outgrowth of the work started at this Station. The success of the work here has made it possible to undertake the new lines at other stations.

APPROPRIATIONS.

The last state legislature were very liberal in appropriations to the Experiment Station. $6,000 was set aside for investigations along animal husbandry lines. An equal amount was given to the work in agronomy. Besides this, $2,000 was given for the erection of a much needed grain and storage building and a like amount for research work in farm mechanics and road building.

As before stated, these funds were not available for the Department until the month of October of the present year. Consequently, their use has been very much curtailed.

The additional land secured for experiment work through the purchase of 80 acres adjoining the experiment farm secured two years ago, has been of great service, but some portions of it are very foul with wild oats and other noxious weeds and these must be thoroughly eradicated before it can be of very great service to us.

With the special appropriations being available for the coming year, it should be a specially noteworthy one. If there is no unforseen setbacks, we feel that the next year will give us something to report that will be especially creditable to this Station.

Respectfully submitted,

W. L. CARLYLE,
Agriculturist.

Fort Collins, Colo.,
Dec. 1, 1907.

REPORT OF AGRONOMIST.

I hereby hand you a summary report of the work attempted and now under way in the Agronomy sub-Section of the Agricultural work of the Colorado Experiment Station.

This spring the Board purchased the Taylor addition to the Experimental Farm—80 acres. This the Agronomy Section used to grow the increase plots—several acres in each—of experimental grains and forage. The general rotation plan for the experimental plat section of the experimental farm is being carried out whereby we hope to carry on plat experimental work and, at the same time, demonstrate a practical rotation for an irrigated farm in this crop zone. Through distribution of definite types of small grains, forage and root crops, followed by crop investigation trips to study these types in their field environment we are seeking to place the most desirable types in their best environment. To help us in our work we have arbitrarily divided the state into three crop zones as follows:

A. Lands below 6,000 feet elevation under the ditch.

B. Agricultural lands in Eastern and Western Colorado without irrigation—above the ditch.

C. Lands above 6,000 feet elevation under the ditch.

Through an organization known as the Colorado Grain and Seed Growers' Association we now have the earnest support of some of Colorado's best farmers in this effort to improve the quality and yield per acre of our agricultural crops through Seed Selection.

The Colorado Seed Grain Competition, made possible through the Premium Fund donated by Hon. T. M. Patterson, of Denver, and the San Luis Valley Pea Prize Competition, made possible by philanthropic citizens of the San Luis Valley, are helping very greatly by showing what seed selection makes possible in crops in wheat, oats, barley and field peas. Through experiments now under way we seek to obtain helpful facts for Colorado farmers as follows:

1. Best varieties of wheat, oats, and barley for High Altitudes, for lower altitudes under the ditch and for non-irrigated Agricultural lands.
2. The best types of stock roots for Colorado conditions.
3. A Colorado type of alfalfa.
4. Relative value of animal and mineral fertilizers in sugar beet culture on Colorado soils.
5. Cultural methods for best results in growing sugar beets.
6. Rotations for different farm conditions in Colorado.
7. Cultural methods for alfalfa and small grain.
8. A desirable Colorado type of Dent corn.

9. Effect of irrigation on gluten contents of milling wheat
10. Forage crops for the non-irrigated lands of the state.
11. Best crop methods for each crop zone of the state.

Mr. F. Knorr, my assistant in the Agronomy work, has been very efficient and thorough in his work and though he has received many offers from other states his interest in our field experiments now under way have influenced him to continue with us.

We hope these Agronomy Experiments when worked out may aid our farmers in obtaining better gains without loss in soil fertility.

Respectfully submitted,

W. H. OLIN,

Dec. 1, 1907.

REPORT OF ANIMAL HUSBANDMAN.

The experimental work with live stock during the summer period has consisted principally in carrying over upon range pastures, twenty head of steers used in the three-year continuous experiment for determining the value of winter feeding of range calves, yearlings and two year olds. The plan of this work has been given in detail in previous reports.

The live stock feeding experiments to be conducted during the coming year are as follows:

THE STEER FEEDING EXPERIMENT.

The conclusion of the three-year experiment by winter feeding of two-year old steers, ending with their sale in the spring.

THE LAMB FEEDING EXPERIMENT.

A ration experiment with range lambs. The lambs have been divided into three lots and are being fed as follows:

Lot 1. Alfalfa hay and corn.
Lot 2. Alfalfa hay and barley.
Lot 3. Chopped alfalfa hay and corn.

The object of the experiment is to determine the comparative values of corn and barley when fed with alfalfa hay; and the comparative value of alfalfa hay whole and alfalfa hay chopped when fed with corn. The experiment will continue for a period of from three to five months.

THE HOG FEEDING EXPERIMENT.

A ration experiment with shotes.

Lot 1. Barley and corn, equal parts; alfalfa hay ad libitum.
Lot 2. Barley and corn, equal parts.
Lot 3. Corn.
Lot 4. Barley and durum wheat equal parts.
Lot 5. Barley six parts, tankage 1 part.

Respectfully submitted.

G. E. MORTON,

Fort Collins, Colo.,
Nov. 1, 1907.

REPORT OF THE VETERINARIAN

To the Director:

The launching of Veterinary College as a department in this institution combined with the extensive farmers' institute work over the state, has prevented, in a large measure, the consummation of plans laid out for work in my last report.

As veterinarian to the Experiment Station, I am constantly in receipts of appeals to investigate outbreaks of supposedly contagious diseases among all species of domesticated animals, and from every section of the state. My duties at the College under the present regime, prevent me from complying with most of these requests, as well as precluding the possibility of any extended research work.

LOCO WEEDS.

The investigation of loco weeds, cooperative with the Department of Agriculture, has been carried on to the present time, with headquarters at Hugo. There are at the present time, seven horses and seventeen head of cattle that survived the summers experiments, in a pasture near Hugo, awaiting the decision of the Washington authorities as to the expediency of continuing the experiments one more year. According to the term of an agreement with the federal authorities, we are obligated not to publish any results of the investigation until the work is completed, and the time of publication as well as the substance of report is to be by mutual consent. The entire experiment has been largely appropriated by the government experts in charge. The results obtained have been highly satisfactory from a scientific standpoint. Their economic value is conjectural.

NECROTIC STOMATITIS.

There is no other disease in the state at the present time that is causing as much apprehension as the so-called sore mouth disease of hogs. It has become widely spread and has decimated many large herds. It is found on almost every farm in several sections of the state. The disease has been known for a long time in the eastern states, but has not been reported as assuming any where near the degree of virulency as it has here. It is caused by a specific germ, the necrosis bacillus, and where as in most instances it has been confined to pigs under three months old, here it is fatal to swine of all ages. Ordinarily the disease is confined to necrotic areus in the mouth, and appears to be purely a local affection. In some instances within the last year, herds have been seen where hogs weighing over

200 pounds were near death, showing large necrotic sores and numerous abscesses on different parts of the body.

Source of Contamination.—The litter, feed troughs and every thing that has been in contact with diseased animals, is a source of contamination. One diseased pig will soon infect the others by nursing and infecting the teats of the mother.

The germ does not develop on a healthy mucous membrane. It seems to develop in the mouths of small pigs when the germs are inflamed from the eruption of the teeth. It soon causes a large inflamed area which becomes necrotic and sloughs leaving large cavernous depressions which continue to grow deeper, until often there are holes clear through the snout, or the tongue is largely eaten away. The system soon becomes intoxicated with the secreted products of the germ which produces nervous depression and stupor. In this condition the pigs become careless of the teat and refuse to nurse, soon becoming greatly emanciated.

Treatment.—Prophylatic measures are effective if wisely and persistantly practiced until the infection is completely exterminated. The theropeutical value of drugs internally administered is questionable.

There is no other one thing concerning farm management and its relation to live stock, about which the average farmer appears to be so lacking in information as in the matter of preventing and effectively eradicating infectious diseases among farm animals.

Lethargy combined with not knowing how, has resulted in most cases of simply allowing the disease to continue until the loss is complete.

Four steps are necessary in the mastery of this disease.

(1) Destroy badly infected animals and burn the carcasses.

(2) Clean up the manure, litter and filth and destroy it by fire. Use disinfectants freely, such as 3% solution of zenolium or any one of several coal tar products, chloride of lime in proportion of four ounces to a gallon of water. White wash the buildings, fences, and everything that may have become contaminated. Burn sulfur in the buildings after closing up the windows and doors.

(3) Remove all animals that appear to be healthy to new quarters.

(4) Dip the little pigs when one week old in a bath composed of potassium permanganate, one ounce to a gallon of water.

The dipping may be repeated at intervals of two or three weeks. The mouths should be examined frequently and any necrotic sores burned out with lunar caustic, being careful not to burn the tongue.

HORSE TYPHOID.

Aside from a few autopsies in the vicinity of Colorado Springs nothing further has been done respecting this disease.

The etiological factor has not been determined and is a subject for the laboratory. The disease is not so widely spread or formidable as to warrant serious apprehension. The aggragate loss is not large but the mortality of animals affected is nearly 100 per cent.

The state of Nebraska has made a special appropriation for the purpose of investigating this disease.

HOG CHOLERA.

Hog cholera appears to have become a fixture in the vicinity of Denver.

The claim made by some that the disease in swill fed hogs adjacent to the larger cities was some disease other than hog cholera, has not been substantiated.

Susceptible hogs were exposed to the disease, by placing them in pens adjoining the sick ones. The usual number contracted the disease, and the symptoms and postmortem lesions revealed the identity of swill sickness and hog cholera. This fact was further substantiated by laboratory experiment and blood serum inoculations.

TUBERCULOSIS.

In reality we have no disease among the lower animals in the West that is commonly classed among the animal scourges. The nearest approach to it is tuberculosis. The disease is not as prevalent here as in the lower altitudes of the eastern states, but every state is being constantly infected by the importation of diseased animals. Aside from the probable menace to the human family it has become an economic problem of such vast proportions as to warrant stringent state and federal regulations.

Tuberculosis affecting several species of domesticated animals has become so general and its complete eradication by the usual methods adopted in exterminating contagiums, is such a stupendous undertaking that the authorities everywhere are overwhelmed by its magnitude and, comparatively speaking, are doing nothing.

Cattle and hogs are the most susceptible and in the latter disease is greatly on the increase.

A few spasmodic efforts have been made on the part of various cities to control the sale of tuberculous animal products for human consumption, (a few states have statutes perporting to regulate the traffic of tuberculous cattle).

The federal government is effectively controlling the sale of the flesh of such animals, for interstate and foreign trade. But until there is a united effort on the part of state and federal authorities to control diseased animals and all the products of the same, there will be very little accomplished.

GEO. H. GLOVER,
Veterinarian.

REPORT OF THE METEOROLOGIST AND IRRIGATION ENGINEER

Such lines of observations as are contained in the work of the meteorologist are the steady, persistant continuation of the series of observations planned and continued for the past twenty years. The value of such is in the length of the series, in the continuation under the same conditions and by similar methods. It is recognized that conclusions cannot be drawn short of a number of years, even concerning some of the simplest facts of climate.

A period shorter than 20 years does not give conclusive data regarding rainfall, temperature or agricultural meteorology. The observations have been directed, not to study the weather—that is done by the U. S. Weather Bureau—but the continuous record of those elements of importance in the growth of plants, temperature, moisture, evaporation, sunshine, and the amount of radiation received from the sun. But very little reduction has been made of the observations hitherto, but now with the completion of twenty years in most lines, it is time to do it. The work of reduction, of putting into shape, means toil far more than does the taking of the observations. The solar radiation, our measurements show, amounts to about 1 horse power per square yard.

The irrigation records of the year have been less with the idea likewise of working up the records available. The lack of room, the dangerous condition of our stores have been serious drawbacks. Records have been continued on streams, on seepage, and on the amount of water used in irrigation. Bulletins on three of these subjects are nearly ready for publication.

THE KANSAS-COLORADO CASE.

The year has seen the final ending of the attempt of Kansas to prevent the use of water in Colorado for irrigation. The final decision was given in May. Afterwards Kansas applied for a new hearing, but within a few weeks, the Supreme Court has again, and finally, declined. This case was largely, if not entirely, fought out on the lines which the investigations of this section had shown to be true; with the additional facilities on a larger scale, and with added wealth of fact and illustration. Immense amounts of records were made, hundreds of miles of levels, and the study of the underground waters for hundreds of miles. The original work has been done with the support of the Board, and therefore, as the credit is distributed, the policy and support of the Board in permitting and encouraging the records

which finally resulted in the victory, is to be recognized. It is a great satisfaction in the final result, for while I have believed that this should be the final result there has been considerable cause for fear, for the doctrine which we urged was contrary to precedent, and the accepted traditions of the east. I have felt and urged that the only way was to show facts and that the equity from the facts would force our case. It has not generally been realized how serious was the contention to the prosperity, not only of the Arkansas Valley, but of the whole of Colorado and of the West. The essential points were: First, a denial of the right to irrigate; and Second, by the U. S., as intervenor, that the United States should control the interstate streams. This last, was after all perhaps the most fraught with danger. It represented the continuation of the policy started in the attempt in the Elephant Butte case, which was not so much to prevent the construction of the dam, as it was to put the control of the streams in the United States. What dangers exist in the United States' control are already seen in the refusal of the general Government to grant land for reservoirs or ditches on the Rio Grande and the Grand River water sheds, on the claim that they might interfere in the one case with proposed schemes in Southern California, and in the other in Southern New Mexico and Texas. An assumption of the power to determine where water may be used, what regions may be developed, and the holding back of communities already well settled in Colorado, in favor of others as yet in the desert.

We have felt that while the investigations leading to these results were aside from those originally planned, that they were fundamental in the Colorado agriculture, and that nothing could be of more importance than establishing the right of the use of water.

For the next year, I now feel that it will be timely and better to bring up our observations than to enter upon much new work, unless there are additional facilities. The many plans elaborately prepared some 15 or 16 years ago, have been followed and all the varied work has been along a general plan and joining in a common end. Many of the plans then made were abandoned for lack of means, until better means were available, and the lines of work taken up were caused by the necessity of incurring small expense.

Respectfully submitted,

L. G. CARPENTER,

Irrigation Engineer.

Fort Collins, Colo.,
Dec. 1, 1907.

REPORT OF THE ARKANSAS VALLEY FIELD AGENT

To the Director:

I desire to submit the following report of the work in the Arkansas Valley.

As outlined, the work during the past season has been principally in line of plant breeding, to improve the three important crops of this part of the state, beets, alfalfa, and cantaloupes.

ALFALFA.

A new enlarged alfalfa nursery was established on a more suitable piece of land, than was first used; the old nursery having become infested with pocket gophers, and the area of uniform soil was limited. The new nursery was sown with seed from choice selected individual plants that had evidence of superior hay and seed producing qualities, and fifty varieties or strains of alfalfa from different states and from foreign countries, that was furnished through Mr. J. M. Westgate of the Department of Agriculture. In all the new nursery comprises sixty-four plats of two hundred hills of individual plants each.

The season was cold and rather unfavorable, yet a very satisfactory stand of plants was secured in most of the plats. A very marked contrast was revealed in some of the foreign strains, some of the plats had tall coarse stems with few leaves, others had thick fine stems very dense set with leaves. The variations in regard to the attack of leaf spot and the tendency to shed the leaves was very pronounced. The contrast in seed production if any thing was more marked than all. One plat sown with seed from Ecuador, South America, produced a remarkable yield of seed on nearly all of its plants, while many plats did not furnish enough seed to make a selection. Notes and photographs, and selections of seed have been made to carry on the work.

Observations have been made during the season on the cultural methods of growing alfalfa hay and seed, with a view of systematic study of the question.

BEETS.

Field observations on the beet crop have been made. The beet crop seems to have been quite generally affected with a leaf spot in this part of the state. Dr. C. O. Townsend pronounced it Cercospora Beticola, commonly called eastern leaf blight. It has seriously reduced the tonnage in this part of the State. Land in fine state of fertility has not been so badly injured as worn out land .

The small plat of mother beets for seed that were being grown to

test the different types of beets, failed to mature seed on account of the false chinch bugs, and other unfavorable conditions.

A test of about forty pounds of the "curly top" resistant beet seed that was produced last year was made with a farmer. The seed was sown at the same time with other seed and had the same care and yet it failed to grow seemingly weak in vitality. The general results in growing beet seed in this portion of the state have not been encouraging.

CANTALOUPES.

Of the rust-resistant cantaloupes, seed of ten that scored the highest in all points of quality were selected for the work the past season. The seed were planted in the same plat, which now for five years has been growing cantaloupes, enough to insure a failure of any ordinary strain of seed, but since the beginning of the resistant selection the plat has revealed a decrease in the presence of the disease, while in adjacent fields the rust has been prevalant as ever, and even more destructive. Except for a few individual plants the plat has been free from the disease. Several practical tests of the rust-resistant strain were made with the commercial growers in the vicinity of Rocky Ford, and in Indiana and Illinois, similar tests were conducted with growers of these states, through the cooperation of Professors C. G. Woobury and J. W. Lloyd of the Experiment Stations. Without exception the reports have all been to the effect that the rust-resistant seed had exceeded the highest expectations, remaining green and producing fine flavored melons after other varieties in adjacent fields were dead with the disease.

A comparative test was made of some varieties secured from W. W. Tracy to determine if there was any other variety that was more resistant to the disease, or that possessed better qualities for market or table, than the strain of seed that we were using. The result was that there was none that was considered better except one from Syrmna that seemed to have a better texture of flesh. An effort to combine this quality by hybridization will be attempted another year.

Also a test of eighty individual melons on alfalfa sod was tried to test the variations and to determine the laws of heredity in cantaloupes. The result of this research can better be given in a more extended report.

Respectfully,

PHILO K. BLINN,
Field Agent.

Rocky Ford, Colo.,
Dec. 1, 1907.

REPORT OF THE WORK AT THE PLAINS SUB STATION

To the Director:

It has been an exceptional year for Eastern Colorado, the worst in the history of the Station, the rainfall at the Station has been less than nine inches from October 1, 1906 to October 1, 1907, and nearly one-third of that at one time, on the 26th of June.

The lowest in any other year according to the Station records being the year 1903, when there were 13.26 inches.

On October 2nd, there were 10 acres of Turkey red fall wheat sown on ground that had been in spring wheat. After the spring wheat had been cut, the ground was well disked and the fall wheat was sown with a disk drill. The wheat was harrowed twice in the spring, but being so short, it was thought best not to cut with binder, so it was mowed, stacked and threshed, making a yield of three bushels to the acre.

On February 28th, there were 7 acres of Macaroni wheat sown, but being so dry, it came up very unevenly and was harrowed twice, was mowed and threshed, yielding 2 bushels to the acre, but of very good quality.

There was also one acre of wheat and two acres of oats sown, ground was disked and sown with disk drill, harrowed twice, for cultivation, but was thin, fairly well filled, and was cut for oat hay.

March 26th, there was planted one-half acre of early Ohio potatoes but during the heavy rain of the 26th of June, they were flooded all night and badly washed out. Will about get the seed back again.

On May 8th and 9th, there were eight acres of corn planted with the lister, but got very poor stand and badly taken by gophers, was cut and shocked but is now in the stack. Yield, one ton to the acre.

May 15th, there was one acre of Turkestan alfalfa sown, seed furnished by the College, but being so dry did not germinate until after the heavy rain of June 26th, and then was so badly washed that it was almost a failure. The other grasses which I sowed last year, such as bromis inermis, western wheat grass and slender wheat grass, have about held their own.

The fruit was an entire failure, owing to the late freezes last spring, but was much better for the trees to rest during the dry season. The growth has been but light, they have held their own but by good cultivation.

The land is in fine condition to go into winter. While dry, I

have all double disked twice, so if there is any moisture whatever it will take it in.

I also took up twenty acres adjoining the Station last June, 1906, plowed and packed it, resting the same till September. Twelve acres were sown to wheat, one bushel to the acre, Turkey red. The other eight acres were sown on September 29th, three-quarters of a bushel to the acre. The entire piece was harrowed three times in April and May, as cultivation. From the day it was sown till the 26th day of June, we had received but two and eleven hundredths inches of rain, this being the night of the big rain of the season. The wheat was cut within the next ten days. Where one bushel was sown the yield per acre was 17 bushels, while that where three pecks were sown, the yield was 21 bushels per acre. The same was all sold at the Station for $1.00 per bushel and sown, as dry as it continues.

Respectfully submitted,

J. B. ROBERTSON,
In Charge.

Cheyenne Wells, Colo.,
Dec. 1, 1907.

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